THE DEPARTMENT OF DEFENSE

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

FISCAL YEAR 1982 PROGRAM FOR RESEARCH AND DEVELOPMENT

STATEMENT BY
THE DIRECTOR OF THE DEFENSE
ADVANCED RESEARCH PROJECTS AGENCY
TO THE 97th CONGRESS
FIRST SESSION
1981

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6 DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

FISCAL YEAR 1982 RESEARCH & DEVELOPMENT PROGRAM, ~~(U)~~

SUMMARY STATEMENT

BY

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BEFORE THE RESEARCH & DEVELOPMENT SUBCOMMITTEE OF

THE HOUSE ARMED SERVICES COMMITTEE,

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I. INTRODUCTION

A. DARPA PROGRAM PLANS AND PROGRESS

Mr. Chairman, I am pleased to present to this committee the Defense Advanced Research Projects Agency (DARPA) budget request for FY 1982. During my testimony today, I hope to convey to you the progress we have made in our major technology thrust areas.

As you know, DARPA serves in a "corporate research" role for DoD. It supports research and technology development for potential future defense missions, advanced technology programs that lend themselves to centralized management, and alternative approaches to current Service mission area developments. In accordance with its charter, DARPA invests funds in high-risk technologies that permit rapid exploitation for high military payoff. The Agency's programs are conducted with industrial, university, and not-for-profit organizations in the private sector and with selected Service R&D laboratories. Our programs are executed through the Services to facilitate later transfer of technology to the appropriate Services.

A review of U.S. investment in military technology vis-a-vis the Soviet Union indicates that the Soviets are exceeding the U.S. investment by a dramatic margin. A technological advantage in new weapons is crucial if the United States is to maintain its war fighting capability; ensuring such an advantage is the basis for the current DoD emphasis on detailed investment strategies. This investment process is analogous to industrial practice, which relates alternative markets and products to alternative mission areas and technologies. The FY 1982 DARPA program plans are focused on nine major technology development areas that can result in revolutionary strategic, conventional, and sea-power capabilities. Our

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nine primary thrusts are in naval warfare; air vehicles and weapons; command, control, and communications; advanced cruise missile technology; land combat; nuclear test verification; space defense; space surveillance; and technology initiatives.

To highlight the current DARPA research and development process and to show the evolution that culminates in an Experimental Evaluation of Major Innovative Technologies (EEMIT) or a capability demonstration program, my statement this year focuses on the EEMIT or demonstration programs and the associated technology base programs for each development thrust. Each of these thrusts is directed to an area of defense concern, and the technology in each will contribute to the U.S. defensive posture in the critical years ahead.

1. Naval Warfare

The DARPA Naval Warfare program seeks new and innovative ways for the surveillance of current and projected Soviet strategic and tactical submarine forces.

In this thrust area, the objectives are to achieve an order-of-magnitude improvement in the performance of passive acoustic sensors and signal processing techniques, to exploit alternative nonacoustic approaches, and to develop multi-sensor data fusion and display to support tactical targeting decisions. These technologies are being developed and evaluated for proof-of-concept demonstration through large-scale, at-sea experiments. Many of these experiments are conducted jointly with the U.S. Navy in a manner that permits both a continuous transfer of technology and an operational input to the development programs.

2. Air Vehicles and Weapons

The objectives of our major air vehicle technology programs are to demonstrate the critical technologies required for low-cost, long-duration, wide area surveillance vehicles, and to provide U.S. forces with an adequate number of improved range, short takeoff and landing aircraft.

The Forward Swept Wing technology demonstration will continue through the design and testing of critical components such as the large-scale aero-elastically tailored composite wings and the advanced flight control system. A final prototype aircraft design will be completed in FY 1981 and fabrication will continue through FY 1982. A joint DARPA/NASA flight test is scheduled for late FY 1983. It is expected to demonstrate numerous range/payloads, low-speed stability, lighter weight, lower cost and other significant factors in the development and acquisition of high-performance aircraft.

The X-Wing vertical short takeoff and landing (V/STOL) aircraft program represents a major innovation in vertical takeoff and landing design and is a combination of basic advances in composite materials, forward swept wing aerodynamics, advanced flight control techniques, and the convertible turbofan/shaft engine being developed jointly by DARPA and NASA. An innovative alternative to this engine is being pursued based on a forward thrust engine that will, if successful, provide an engine suitable for near-term operational use for approximately five percent of the cost of a new V/STOL engine.

In the air vehicle technology base area, DARPA-sponsored efforts in rapid solidification rate (RSR) technology have resulted in a superalloy that has many orders-of-magnitude increase in high-temperature performance

over conventional aluminum alloy fabrication technology. DARPA will pursue the application of RSR to other high-performance alloy materials. These advances are expected to be transferred to appropriate Air Force and Navy RSR technology development programs upon demonstration and validation of the techniques.

3. Command, Control, and Communication (C^3)

DARPA developments in basic computer science research, combined with the application of very large-scale integrated electronics, show great promise for establishing a basis for a wide spectrum of future military systems involved in strategic and theater command and control (C^2). These technology base programs are the foundation for a number of real-environment testbed demonstration programs being conducted jointly with the Services. These testbed programs will provide an excellent and natural means for integrating and evaluating advanced information processing technology into critical C^2 functions. Currently, three major testbed activities are being conducted: the Advanced Command and Control Architectural Testbed (ACCAT) with the Navy, the Fort Bragg Packet Radio Testbed, and a strategic C^3 experiment that is a joint effort with the Defense Communication Agency (DCA) and the Air Force Strategic Air Command (SAC).

The ACCAT facility, located at the Naval Ocean Systems Command (NOSC), provides a realistic C^2 context for demonstrating and evaluating a broad range of information processing technologies using operational Navy databases. ACCAT is also a vehicle that can be used to introduce future capabilities to planners, developers, and potential users of advanced C^2 information processing techniques. Integrated use of geographically distributed computer databases and remote updating of computer software are two of the more promising techniques being developed.

The DARPA/Army Data Distribution System (ADDS) testbed is a jointly operated system located at Fort Bragg and used by an Army Corps to evaluate operational and doctrinal impacts of computer-based information processing in the tactical battlefield. Field use of automated tactical reporting systems, automatic load planning, and resource management concepts and software are being evaluated on an unclassified basis. Modification of the testbed to permit secure information processing will be accomplished during FY 1982 and will include evaluation of classified functions during real-time tactical exercises in the field. This testbed activity is based on DARPA-developed mobile packet radio communication technology and advanced computer internetting techniques that permit a wide variety of packet networks to be interconnected. The original 5-node network has been expanded to 20 nodes, and participation in a major field exercise (Solid Shield) is planned during FY 1981.

An experimental strategic C^3 experiment is being designed that will incorporate advanced technologies such as airborne packet radio, end-to-end network security, and distributed databases for application to reconstruct selected C^2 capabilities during and after a major attack on the United States. ARPANET has been installed at SAC Headquarters and an analysis has been initiated on SAC crisis C^2 information flow. Airborne experiments with existing packet radio equipment have been conducted to validate system operation with aircraft and to simulate SAC airborne and ground mobile C^2 activities.

These testbed activities represent the outgrowth of technology base research in basic computer science and computer communications technology. The purpose of the research is to form a basis for achieving secure,

geographically distributed information systems as well as information processing techniques that exhibit a high degree of intelligent function or behavior. For example, a "kernelized" (i.e., software coding security safeguards) computer software system has been implemented, and design of the ADA programming language was completed and accepted as a DoD standard. An ADA-based programming environment for distributed information processing systems will be developed and demonstrated in FY 1982. As it is developed, the results will be transferred to the Services through the various testbed programs. A program to investigate key technology elements of a strategic communication system for data exchange with submarines will continue in FY 1982.

4. Advanced Cruise Missile (CM) Program

DARPA continues to direct its efforts in this area on expanding the technology base for improving the U.S. cruise missile fleet and to provide fundamental, new capabilities for the future fleet. Evolving Soviet developments indicate that technologies must be addressed that will counter the evolving threats. DARPA technology base investment strategies are directed toward achieving longer range and reduced vulnerability. A combination of technologies has been selected to compound the problem of CM detection and acquisition. Efforts continue on the four major elements--autonomous terminal homing, advanced delivery concepts, advanced engine, and CM detection technology.

a. Autonomous Terminal Homing. During prior work, two sensor types, scene-matching algorithms, and a reference map preparation approach were selected. FY 1981 efforts include fabricating the sensor and developing a ground-based Scene-Matching Laboratory. During FY 1982, a

sensor flight test and evaluation program will be conducted in which scene-matching algorithms will be evaluated and a single sensor/scene-matching combination will be selected. Pending successful flight testing, these technologies will be transferred to the Air Force for potential implementation in its advanced CM technology programs.

b. Advanced Delivery Concepts. Unconventional designs and launch modes as well as a variety of subsystem technologies are being examined that can provide substantial increases in range payload and improved defense penetration capability. A flight vehicle technology demonstration program will be initiated during FY 1982 to validate these capabilities. Work also will continue on preliminary subsystem designs for a nonnuclear CM.

c. Advanced CM Engine. Development and test of selected engine configurations have been initiated and a concept validation phase will begin in FY 1981.

d. CM Detection Technology. The principal efforts during FY 1981 were devoted to measuring and analyzing propagation phenomena and related environmental factors. More detailed measurements and development of an environmental model will be accomplished during FY 1982. When completed, this program is expected to provide a basic physical understanding of the effects that limit CM detection.

5. Land Combat

Prior technology base investments in infrared detector arrays, missile guidance techniques, and warhead technology provide the basis for two major new demonstration programs to strengthen U.S. conventional forces--Tank Breaker and Assault Breaker. Tank Breaker is a joint DARPA/

Army program to develop the technology for a lightweight shoulder-fired fire-and-forget missile to be used in the main battle area. Several candidate Tank Breaker prototype systems have been designed, and component fabrication has been initiated. Based on component testing and preliminary system design, two contractors will be selected during FY 1982 to fabricate and perform controlled flight tests. Transition of the prototypes to the Army for completion of development testing is planned during FY 1983. The Assault Breaker program is a joint DARPA/Army/Air Force development program to demonstrate component and system technology for a nonnuclear, standoff weapon system capable of engaging and destroying a sizeable force and thus negate a serious Warsaw Pact threat in Central Europe. The integrated system will include missiles, surveillance and guidance radar, and munitions dispensers. In order to demonstrate fully the weapon delivery options of the concept, a joint DARPA/Air Force test of an air-launched version of a standoff missile will be conducted during FY 1982. Successful demonstration of Assault Breaker technology during FY 1982 will provide a basis for engineering development decisions on the weapon guidance radar by the Air Force and on elements of a potential Corps support weapon system by the Army.

Current or proposed investments in land combat technology base developments are directed toward substantial improvements in critical defensive systems.

A hybrid signal processing development program is being conducted to achieve radar signal-to-noise ratios that cannot be achieved with conventional approaches and that can be applied to a wide spectrum of radars. In FY 1982 a full analog/digital signal processor and support

system will be developed and tested. Research in CM defense has been initiated to develop a counter to the next generation CM threat.

An outgrowth of the Sanctuary Bistatic Radar program described last year has resulted in initiation of a joint program with the Army to provide responsive and accurate alerting and cueing information to battlefield air defense weapons such as Stinger, SHORADS, and DIVADS. A small, low-cost receiver is being developed to operate with existing radar systems and to provide a substantial improvement in engagement capability and survivability. This program will transition to the Army for incorporation into its SHORADS-C^2 testbed.

A joint DARPA/Navy electronic warfare program has been initiated to provide increased effectiveness for optimizing electronic countermeasures techniques operating against hostile fire control radars. The program applies to a number of air-to-air and ground-to-air uses and has shown considerable promise in preliminary laboratory tests. Field tests of surgical countermeasures techniques are planned for FY 1982.

A significant improvement in cannon artillery is the purpose of a joint DARPA/Army effort. The primary objective for developing a fire-and-forget cannon artillery projectile is to overcome the inherent range and accuracy limitations of artillery. A next generation of artillery, capable of interdicting armor beyond line of sight, may be achieved as a result of a joint DARPA/Army critical technologies demonstration. Advanced infrared terminal homing, projectile propulsion, and projectile guidance techniques will be demonstrated. We are presently in a captive flight test phase of competing concepts, which will be followed by integration of the critical components into a prototype projectile in FY 1982 and live firings in FY 1983.

6. <u>Nuclear Test Verification Technology</u>

A firm technological base has been developed on which U.S. negotiating strategy and technical positions can be established for nuclear test limitation agreements. During FY 1982, this program consists of a marine seismic system (MSS) demonstration and technology base investments for an International Seismic Data Center and basic research to improve the U.S. capability to estimate the yield of foreign underground nuclear tests.

The MSS program will demonstrate the feasibility of installing and operating a state-of-the-art sensor in the deep ocean floor and will be used to determine the potential seismic detection capabilities of such a system. The MSS will substantially enhance our capability to monitor a comprehensive test ban treaty (CTBT) or to validate nonproliferation agreements.

The International Seismic Data Center program supports anticipated CTBT requirements and the need for advanced signal processing techniques that can evaluate regional seismic data. A prototype data center is being planned that will be capable of processing information from national seismic stations as well as a testbed for advanced verification processing procedures. The first operational prototype data center will begin processing data in FY 1982.

The DARPA Yield Estimation Research program supports investigation of basic seismic signal research recorded at long distances to improve U.S. yield estimation of foreign tests. Earth structure phenomenology and behavior of geologic materials are being examined to reduce measurement uncertainties through detailed understanding of the fundamental physical processes involved in seismic propagation.

7. Space Defense Technology

DARPA Space Defense Technology programs are grouped into the two major investment areas in which a considerable payoff in capability is anticipated--high energy laser space defense and particle beam propagation.

Talon Gold, ALPHA, and the Large Optics Demonstration Experiment (LODE) collectively address development of the required technologies for a space-based laser system that can perform a variety of defensive missions.

The Talon Gold program utilizes laser radar techniques developed under its technology base program to achieve the required tracking and precision pointing. Competitive preliminary system designs have begun and will be reviewed. At that time, a single contractor will be selected for the fabrication and evaluation phases. Space experiments will be conducted in a space shuttle sortie.

The program objective of ALPHA is to demonstrate high energy laser device feasibility. Detailed design of laser subsystems will be completed and fabrication will begin. Concurrently, the design of the ground test facility will be initiated. This program will transition to the Air Force upon ground demonstration of laser device feasibility.

The LODE program will establish the feasibility of large aperture beam control for a high energy space laser system. If the LODE program succeeds, it will be due to the considerable achievements of previous technology base programs. For example, the Large Optics Technology series of programs recently completed established the basic feasibility of mirror fabrication techniques; other programs established critical LODE system parameters that include beam control performance and vibration isolation.

Construction of an Advanced Test Accelerator (ATA) will be completed during FY 1982 and will be used to perform critical experiments on the feasibility of propagating intense charged particle beams within the atmosphere. ATA will provide the essential data required by the Services to plan for and design preprototype weapons. Additional efforts during FY 1982 are directed toward subsystem assembly and checkout. Initial beam experiments will be performed during FY 1983.

The current successful pace of laser and particle beam experiments reflects a number of space defense technology base investments that include laser optics technology, acquisition and tracking techniques, and laser device/particle beam component technology.

8. Space Surveillance

The Teal Ruby Experiment and the Advanced Sensor Demonstration are space experiments incorporating first and second generation DARPA infrared detector array technology. The sensors utilize a "staring" concept for high sensitivity, high-resolution detection of low-energy targets against earth background clutter.

The Teal Ruby space-based experiment will be launched by space shuttle in FY 1983, and the Advanced Sensor Demonstration is planned for shuttle launch to synchronous orbit during FY 1987.

Technology base activities that enabled confident pursuit of the two space experiments include the High Resolution Calibrated Airborne Measurement program (HI-CAMP), which provided two-dimensional measurements of earth backgrounds and various targets using a prototype two-dimensional "staring" infrared array detector. The HI-CAMP sensor will provide fundamental atmospheric, target, and background measurement data and assess

advanced infrared two-dimensional detectors and signal processing techniques. Global year-round background data will be collected in a number of spectral bands during FY 1982 using existing and higher performance infrared sensors. The DARPA Space Based Radar technology development program is directed toward developing the critical component technologies required to permit space fabrication and operation of a large-scale phased array radar. Primary missions include fleet defense and CONUS air defense. Development of very large-scale gallium arsenide integrated circuits is also being pursued; this offers the potential for a substantial increase in radar signal processing speed and/or power advantages that are important for space-based operation as well as for electronic equipment in other environments requiring low power, high radiation-tolerant integrated circuits. A complete technology for ion-implantation has been demonstrated and is being applied to DARPA sensor testbed systems and to Naval Air Systems Command programs.

9. Technology Initiatives

DARPA continues to invest in innovative concepts and ideas that can significantly reduce the cost of weapons and substantially increase defense capabilities. The exploitation of advanced computer-based information processing technology is being pursued to provide automated decisionmaking aids for national and theater-level crisis and battle management. Objectives of the DARPA Teleconferencing Technology program are to develop and demonstrate conference control techniques for a decisionmaking group in which each member is at a different location. Current C^2 system design has not addressed this problem beyond providing a variety of communication and data management equipments. Based on transmission of low

bandwidth video, the Teleconferencing Technology program will provide a shared virtual space in which all of the conferees are gathered around a common meeting space. Virtual space technologies are made possible through the development of a unique computer processing procedure that enables the transmission of image sketches. A three-station local area video teleconferencing system is based on the shared virtual space concept and incorporates data sharing, joint document production, and meeting control. A three-station experimental distributed system has also been developed to identify problems associated with a distributed system.

During FY 1982, the design of the local and distributed systems will be modified to include an acoustic management procedure and a high resolution electronic blackboard. Our Distributed Sensor Network program also addresses distributed computer architecture techniques and is investigating a survivable surveillance system based on packet radio technology to link together multiple low-cost distributed sensors. A fully distributed surveillance system offers a non-nodal, highly dispersed system that can be most effective for detecting and tracking low-flying aircraft or for linking a variety of different sensors to provide an overall situation assessment. This effort will result in a computer system architecture for networks of distributed sensors.

These initiatives involve a fundamental examination of the limits of digital computer capabilities to perform intelligent information processing for military functions. Our Machine Intelligence research program is directly concerned with developing innovative methods of converting large amounts of specialized knowledge into a database and to efficiently bring that knowledge to bear on complex and dynamic problems of strategic

or tactical situation assessment, planning, and control in the C^2 environment. The objective of this work is to utilize computers to assist or relieve military personnel of decisionmaking tasks that are information intensive, personnel intensive or in environments that present large amounts of information in unexpected situations.

One important product of our concentration on advanced electronics and information processing technology is a joint DARPA/Air Force space signal processing development that is intended to configure an onboard signal processor with a multimission flexibility that is optimized to support military space missions through the year 2000. The processor will process raw sensor data, relieve the communication system, and provide a number of antenna configuration and control functions. Originally developed for the Space Radar program, it became apparent that the design was general enough to encompass all known space signal processing requirements.

These, then, are the nine major DARPA thrusts for FY 1982. In addition to these, technical assistance is being provided to Unified and Specified Commands on potential applications of DARPA technology developments to specific command problems. At the request of the DCINC/EUCOM, we provided technical support for development of a packet-switched network (MINET) that is intended to integrate several U.S. military sites in Europe and to provide interactive access to distributed computers for logistics management. A military message experiment was conducted at PACOM Headquarters to assess the functional utility of automated message handling for the Commander. A state-of-the-art interactive message handling system was developed to create, edit, coordinate, release, and forward messages within the command. DARPA also was requested to examine technological options for

improving the combat effectiveness of the Combined Forces Command-Korea (CFC-K). An initial assessment has been completed and suggestions have been made to CFC-K for near-term improvements. As a result of a request from the Air Force SAC, an evaluation was conducted to identify advanced information processing technology alternatives for managing strategic force mission planning and execution. A report was prepared for SAC which included a recommendation to shift to highly proliferated assets with intensive use of computer processing for C^2.

B. CONCLUSION

Mr. Chairman, I have briefly reviewed the highlights of the proposed research and technology program for FY 1982. More detail and summaries of additional programs that emphasize technical progress are presented in the Section II thrust descriptions. The requested FY 1982 budget for this program is $655.0 million. A summary of the proposed application of these funds is provided in Section VI of my prepared statement.

II. THE DARPA BUDGET REQUEST - FISCAL YEAR 1982

A. NAVAL WARFARE

1. EEMIT or Demonstration Programs

DARPA is not currently funding any EEMIT or demonstration programs in this program area.

2. Technology Base (6.1/6.2) Programs

a. Acoustic Research Center (ARC). The ARC is an advanced signal processing testbed that enables acoustic surveillance research, development, test, and evaluation in a real-world environment for eventual implementation into the sound surveillance system (SOSUS) without interfering with basic SOSUS operations.

The actual ARC consists of a number of high speed digital computers and peripheral support equipment that are used as research tools to develop advanced signal processing algorithms for incorporation into the SOSUS network. To achieve this capability, wide band, secure, dedicated, digital communications links are provided to the principal Navy laboratories working on the long range surveillance problem.

The ARC testbed concept enables orderly development, testing, and debugging of advanced signal processing techniques to provide a focus for long range upgrading of the SOSUS processing software/hardware set and to provide proven computer software for near term SOSUS updates. This testbed also allows for meaningful demonstration of alternative processing concepts.

Using the coherent inter-array processing (IAP) originally developed and demonstrated at the ARC in FY 1976, the FY 1980 thrust has been to increase the overall efficiency and speed of the signal processing

algorithms to perform increased broad area ocean search. In late FY 1980, a real-time search was conducted that systematically covered a 750,000 square mile aréa. In late FY 1981, new optical processing techniques will be used with the potential to increase the area covered by at least two orders of magnitude, culminating in a potential one-million square mile, real-time search demonstration. In addition to exploring techniques of near-term operational utility, the ARC participates in long time scale data collection to document the changes in ocean acoustic conditions caused by storms, major frontal weather movements, and related natural phenomena. Based on finalization of the ARC system configuration in FY 1981, the facility will formally transition to the Navy in late FY 1982.

b. Nonacoustic Antisubmarine Warfare. The acoustic detection of submarines is well advanced. Because its potential has nearly been met and any additional significant advances can be expected to be expensive and difficult to implement, alternative nonacoustic approaches to submarine detection must be systematically studied. These high-risk, innovative approaches must define and address areas of long range promise and assess the vulnerability of our own units to comparable counterdetection measures.

The Nonacoustic Antisubmarine Warfare program is an all-encompassing research effort to explore the potential of submarine detection based on observed changes in the ocean environment caused by the submarine's presence. As the name implies, the program complements acoustic detection methods and includes techniques that do not depend on active sonar transmissions or passive acoustic emissions from the submarine. Successful nonacoustic detection techniques will require a full understanding of the ambient ocean environment as well as an assessment of submarine-

induced observables. An examination of potential observables useful for detection is under way, and two highly promising sensor techniques have been transferred to the Navy.

In FY 1980, all previous related DARPA work was transferred to the Navy for future independent development. DARPA continues to take the lead in developing airborne sensors to detect the submarine hull. A laser hull detection model was developed and efforts are now under way to expand the model to consider other observables. Special survey instruments are being built to allow a scan of ocean optical properties in conjunction with routine hydrographic studies to characterize the background environment. By mid-FY 1982, the technical assessment will be complete and a capability demonstration program will be defined. The DARPA work is directly coordinated with the larger Navy nonacoustic efforts; program results are transitioned directly.

c. Remotely Guided Autonomous Lightweight (REGAL) Torpedo. REGAL is a technology base program to develop, evaluate, and demonstrate the technological feasibility of advanced guidance and acoustic sensor concepts that will significantly improve the target acquisition range of advanced lightweight torpedoes. The REGAL torpedo is an antisubmarine warfare weapon that integrates into a single weapon system an acoustic array and advanced signal processing. Upon water entry, the acoustic array and the torpedo separate, with the array descending to a preset depth while the torpedo conducts a slow speed target search.

Successful development of the REGAL technology base will provide the basis for demonstrating autonomous guidance of the torpedo by means of a communications link to a sensitive acoustic array. This will

enable longer detection, acquisition, and track ranges.

An initial REGAL development effort, emphasizing subsystem feasibility and design, produced a prototype that was tested during FY 1980 to evaluate the performance of the guidance and control software. A series of fully autonomous sea runs are being conducted during FY 1981 to evaluate REGAL performance as a function of sensor-target-torpedo geometry, weapon speed and maneuver, target range for handover from stationary to torpedo on-board sensors, and target signal-to-noise ratio. The FY 1982 program will continue to be heavily sea-test oriented, with sea runs becoming progressively more complex as target dynamics are introduced along with the integration of the newly developed brassboard sensor. The final demonstration test series, when completed in FY 1983, will demonstrate the integrated technology base that is necessary for a lightweight torpedo. The REGAL technology base, which is very closely coordinated with ongoing Navy advanced lightweight torpedo and antisubmarine warfare standoff weapon development, will transition to the Navy at the end of FY 1983.

d. Ocean Tactical Targeting (OTT). The OTT program uses advanced processing and communication technology bases to focus on an area of tactical interest and to develop a scene description of sufficient accuracy, resolution, and completeness to support targeting decisions by the local commander. The OTT concept is based on a multisensor data fusion center that combines raw, intermediate, and output level data from broad area ocean surveillance sensors. It generates geographic, parametric sensor cues to obtain further information. An advanced signal processing capability within each broad area sensor responds to cueing and feedback information from the fusion center. Successful technology base development of

the OTT concept will result in the ability to accurately locate and identify all platforms in a specified area of tactical interest through the exclusive use of broad area ocean surveillance sensors. This unique approach will maximize the use of existing sensor systems without interfering with their basic missions. At the same time, it will demonstrate a fundamentally new technique of designing future sensors.

Initial research tasks in database management have been completed along with the objectives, schedule, and support (ship, communications, facilities) arrangements for an experiment. This experiment will provide for a limited demonstration of OTT and will stress the collection of data for FY 1982 analysis and evaluation. Subsequent efforts will be on the design and development of prototype fusion center real-time operation and adaptive sensor signal processing, culminating in a major fleet demonstration in FY 1984. The OTT technology base, which is a joint DARPA/NAVELEX program, is planned for transition to the Navy by FY 1985.

B. AIR VEHICLES AND WEAPONS

1. EEMIT or Demonstration Programs

a. Forward Swept Wing (FSW). A manned FSW aircraft made possible with an advanced composite structure and a digital fly-by-wire flight control system will be designed, fabricated, and flight tested to investigate and quantify the aerodynamic characteristics and performance capabilities of this integrated advanced technology vehicle. The program has the potential to achieve major technological breakthroughs in the areas of structures, aerodynamics, stability and control, and configurational design freedom. The flight test will develop confidence in numerous individual technologies, make them viable design options for advanced flight vehicles, and reduce the risk and time associated with their future application.

This program has been structured to demonstrate that advanced composite structures can solve the aeroelastic divergence phenomenon, a static structural instability experienced by forward but not aft swept wings. By solving the divergence problem, a thorough investigation and exploitation of the benefits long attributed to the forward swept wing configuration will be possible, stressing improved maneuverability, low speed and high angle of attack performance, and the considerable design flexibility. Completion of the program through flight test will ensure a credible audit trail from theoretical analysis through design, fabrication, and test, which will enable rapid maturation and acceptance of the pertinent technologies.

Analysis indicates that an FSW tactical aircraft could be as much as 25 to 30 percent lighter than an equivalent aft-swept aircraft or have equivalent range/payload performance improvements. The excellent low-speed stability and control characteristics, higher lift capabilities of the FSW design and enhanced transonic performance available without transonic drag penalties all promise revolutionary capabilities where runway denial is an operational concern or for operation from small ships.

The foundation of the FSW program is based on two decades of composite material research and exploratory development, with special emphasis on the analysis and design techniques developed by the Air Force to aeroelastically tailor wing structures. NASA airfoil design analysis tools were used extensively in the supercritical airfoil designs along with numerical techniques of the inviscid flow model used to determine aircraft structural load distributions. The aerodynamic and structural design techniques developed for the NASA/Air Force high maneuverability aircraft

technology (HIMAT) program were also used for FSW analysis. The results of 10 years of Air Force, Navy, NASA, and industry digital flight control design programs are integrated into the proposed FSW flight control system.

Conceptual studies, design analyses, and wind tunnel testing have shown that excellent low-speed handling qualities and short takeoff and landing capabilities, attributed to the configuration for years, are indeed possible. Wind tunnel tests have also documented increased aerodynamic efficiency through improved lift characteristics and reduced drag levels. Large-scale aeroelastically tailored composite wings that were designed, fabricated, and tested have demonstrated conclusively the ability to solve the aerodynamic structural divergence problem. Successful analysis, design, and test of a flight control system with a man-in-the-loop simulation have demonstrated the capability to control the high static instability in the FSW configuration. Final design will be completed and fabrication started during FY 1981, continued through FY 1982, and culminate in a flight test in late FY 1983. A joint DARPA/NASA flight test is planned with further transition of data to the Services following flight test.

b. X-Wing. The X-Wing is a major innovation in vertical takeoff and landing (VTOL) aircraft design which, by stopping the rotor in flight, combines the vertical lift efficiency of a helicopter with the speed, range, and altitude performance of a transonic fixed-wing aircraft. The objective of this effort is to design, fabricate, and flight test a demonstration vehicle of a size representative of an operational aircraft. The unique X-Wing capability is made possible through circulation control, a system by which the lift on each rotor blade can be selectively

controlled by varying the momentum flux of air blown through tangential slots along each rotor trailing edge. The X-Wing aircraft uses the circulation control system to produce lift and achieve stability and control of the vehicle during all flight modes, including in-flight stopping/starting of the rotor wing. Design analysis indicates an operational X-Wing vehicle would have approximately three times the range, speed, and altitude performance of a conventional helicopter with equivalent payload lifting capability. Such characteristics would greatly enhance all current VTOL missions and could provide flexible sea-basing and deployment options for the Navy, in addition to providing new capabilities for all the Services.

The X-Wing VTOL initiative was derived from the circulation control rotor work performed earlier by the David Taylor Naval Ship Research and Development Center. It also takes advantage of advanced stopped rotor dynamics and control work done by the Army in the late 1960s. The Navy is using a 49-ft diameter circulation rotor concept in a current flight test program on the UH-2D helicopter to demonstrate improved reliability, maintainability, and active vibration suppression. Also, the wing of an A-6 aircraft was modified by the Navy to demonstrate circulation control for short takeoff and landing performance improvement and completed a very successful flight test program, during which minimum landing speeds were reduced from 120 knots to 75 knots. The X-Wing program will demonstrate the synergistic impact of basic advances achieved in diverse areas such as advanced composite materials, forward swept wing aerodynamics, and advanced digital fly-by-wire control systems. Additionally, a joint DARPA/NASA convertible turbofan/shaft engine program is being conducted in parallel to demonstrate a new and more efficient propulsion system for the

X-Wing program or other vertical/ short takeoff and landing aircraft concepts.

Significant technical successes, recognized program maturity, and broad potential operational applications resulted in rapid evolution of the X-Wing program during the third quarter of FY 1980 to permit a flight assessment of the concept with operational similitude. In response to a restructuring directive, initial competitive efforts were under way by the beginning of FY 1981 that emphasized multi-Service application studies, detailed design of a large scale rotor and control system, preliminary design of an operational-size flight demonstrator vehicle, and preparation of a detailed program development plan. A low-cost modification of the TF-34 engine is being pursued in a related program. This modification would enable the TF-34 engine to produce forward thrust and shaft power for the X-Wing vehicle; its successful completion could provide a developed, operational engine for approximately 5 percent of the cost of a new VTOL engine. It is anticipated that the program will transition to the Navy at the end of FY 1983.

2. Technology Base (6.1/6.2) Programs

a. Rapid Solidification Technology. Rapid solidification technology applies to alloy systems that are cooled very rapidly from the molten state to a solid at rates ranging from one thousand to one million deg per sec. Methods for achieving these high solidification rates include atomizing the liquid to fine droplets that produce alloy powder; impinging a stream of molten alloy against a rotating, cooled cylinder, which produces solid alloy ribbon or flake; and melting a thin surface layer by means of a laser or an electron beam, which rapidly solidifies onto the

underlying solid. Such techniques have been applied to aluminum alloys, high-temperature nickel-base superalloys, and high-strength steels.

The principal benefit of rapid solidification is the enormous improvement in alloy chemical homogeneity. When compared with conventional ingot processing methods for nickel-base superalloys, this homogeneity yields alloys with an increased temperature capacity of 200°F. Other positive effects include very strong aluminum alloys that have the properties of titanium, load-bearing steels capable of carrying tremendous loads, and exciting alloys for batteries, magnets, and catalysts.

DARPA-sponsored efforts in rapid solidification technology have resulted in a superalloy that contains no chromium or cobalt and has over a 20-times increase in high-temperature creep resistance, aluminum alloys that have demonstrated a 30-percent increase in specific stiffness and a 100-times improvement in life under cyclic stress, and stainless steels that contain alumimun instead of chromium. DARPA expects to soon demonstrate a scale-up of high specific stiffness aluminum alloys and expand exploration of new rapid solidification techniques as applied to other high-performance alloy systems. The Services, particularly the Air Force and the Navy, have ongoing programs in rapid solidification technology, and it is expected that several DARPA technology developments will be transferred to Service advanced technology demonstration efforts.

C. COMMAND, CONTROL AND COMMUNICATIONS (C^3)

1. EEMIT or Demonstration Programs

a. Advanced Command and Control Architectural Testbed (ACCAT). The ACCAT is a testbed at the Naval Ocean Systems Command (NOSC) that was established to explore the applicability of advanced information

processing technology tc operational Navy systems. Remote sites at the Naval Postgraduate School, Commander in Chief Pacific Fleet, and Fleet Numerical Oceanographic Center are linked to the central site at NOSC over a secure subnet of the ARPANET. A shipboard mobile access terminal will provide secure access to shore-based databases via a Navy communications satellite link to the ARPANET.

ACCAT provides a realistic command and control context for demonstrating and evaluating a broad range of information processing technologies including natural language access to geographically distributed databases, remote maintenance of software, and device-independent graphic systems. Naval users are able to evaluate these technologies using operational Navy databases. A naval warfare environment simulator provides an interactive environment for conducting realistic command and control exercises from the remote sites. The ACCAT will introduce planners, developers, and potential users of future command and control systems to state-of-the-art information processing capabilities.

ACCAT utilizes packet switching network technology, including end-to-end security on the ARPANET, a high bandwidth local command center network, and internet technology to link the Navy communications satellite to the ARPANET. Development of the natural language access to databases and the ability to reliably support databases located at geographically separated sites resulted from research in intelligent systems and advanced network concepts.

A distributed database management system has been developed and demonstrated. It will be demonstrated further in FY 1982 using existing operational Navy databases. A naval warfare environment simulator has been

developed and is in daily use from the ACCAT central and remote sites. A breadboard mobile access terminal has been developed and will be tested in FY 1982 between a deployed ship and a shore-based command center. A device-independent network graphics system is being integrated with the distributed database management system, and a graphics editor is being developed to permit geographically separated command and control users to prepare and present situation and status information graphically. The ACCAT will be transferred to Navy management at the end of FY 1982.

b. Fort Bragg Packet Radio Testbed. Based on a Memorandum of Understanding among DARPA, U.S. Army Training and Doctrine Command, Development and Readiness Command, and the XVIII Airborne Corps, the DARPA/Army data distribution system (ADDS) testbed is a jointly operated system used by the Corps to evaluate experimentally the operational and doctrinal impact of the use of information processing in the tactical battlefield. A packet radio computer communication network at Fort Bragg, North Carolina, is connected through gateways to the ARPANET and provides the Corps with access to selected computing resources to support experimental field and garrison operations. Numerous application software packages have been developed to support field use of automated tactical reporting systems, automatic airborne load planning, record keeping, and resource management.

Computer-based battlefield information systems are expected to place demands on communication technology that the Army has not heretofore explored. This testbed effort forms the basis for Army-designed experiments in field use of computer resources to support command, control, and logistics functions. The plan calls for securing the system in FY 1982 to allow the technology to be employed in classified field exercises, which

will provide feedback to the Army on operational and doctrinal impacts and information to DARPA on system performance.

The packet radio testbed is intended to provide the potential tactical users of battlefield information processing systems with early access to the technology to assess its utility and to formulate ideas for new applications in distributed automated data processing. The early exposure and feedback will also serve to guide DARPA research and development initiatives toward areas deemed the most promising by future users.

This testbed effort is based on the DARPA-developed mobile packet radio communication system and the internetting technology that allows a wide variety of packet networks to be interconnected to support computer communication across and among systems connected to any of the constituent networks. Proven application software--such as message and database management systems--as well as experimental applications such as automated airborne load planning, tactical status reporting, and fire control form the core of the user utilities supported by the combined packet radio and ARPANET system.

The 5-node, initial packet radio network at Fort Bragg has been expanded to 20 nodes. An automated, airborne load planning system has been implemented, is in regular use, and is being expanded to support additional aircraft types. Two field demonstrations have been successfully carried out and a major field exercise (Solid Shield) is planned in 1981. Early in FY 1982, packet radios will be used to support experiments with automated fire control at Fort Sill, Oklahoma; later that year, the packet radio network will be secured to support classified field exercises at Fort Bragg. The testbed system will be made available to the Army at the

completion of the joint DARPA/Army technology assessment effort (approximately FY 1983).

c. Strategic C^3. The strategic C^3 experiment is a cooperative project of DARPA, the Defense Communications Agency (DCA), and the Strategic Air Command (SAC) to demonstrate the feasibility of using advanced technologies to support survivable trans- and post-attack command and control. An experimental system is being created by which advanced technologies such as airborne packet radio, end-to-end network security, and distributed knowledge and data bases may be evaluated and applied to reconstruction of selected command and control capabilities during and after a major attack on this country. The program specifically focuses on the reconstitution of surviving communications and strategic forces following a nuclear attack in the context of the broader national command and control mission.

Staff of the SAC are being introduced to computer communication reconstruction concepts through the installation of ARPANET facilities in the headquarters, numbered air forces, and Air Defense Command. The communication range of packet radio network technology is being extended for airborne use and will provide automated services to airborne assets, such as the airborne command post. Concepts will be developed to facilitate automated support of distributed command and control. The experiment will provide flexible and survivable automated support to the SAC staff so that doctrine for employing such facilities for crisis management can be established and tested in concert with technological development.

The concept of automated support for distributed command and control in an airborne environment is made possible by the existing packet

radio technology. End-to-end security techniques are being developed to provide full security for the system. Distributed and replicated data base management techniques currently under development will be tailored to this application.

ARPANET access has been provided at SAC headquarters and selected staff are gaining familiarity with it. An analysis of SAC crisis command and control information flow is under way. Airborne experiments with existing low-power packet radios have been conducted at short range to validate the system's operation with aircraft and to simulate SAC airborne and ground mobile command and control activities. Airborne testing will continue in FY 1982 with military aircraft, and a high-power packet radio amplifier will be completed to extend its range to several hundred miles. The distributed database management system developed for ACCAT will be utilized to replicate databases for data survivability. This program will be transitioned to the Air Force in FY 1985.

2. Technology Base (6.1/6.2) Programs

a. Basic Computer Science. Basic computer science research is developing fundamental new information processing technology that will form the basis for future military systems. This includes research in certifiably secure operating systems to support multilevel security applications, distributed processing for increased survivability, and system development environments based on the high-level language ADA developed by DARPA. Efforts are also directed at applying machine intelligence concepts to make information systems easier to use and at developing architectural alternatives for C^3 applications, including distributed message systems, which are at the core of military communication requirements.

The results of this research will form the technological basis for building secure, geographically distributed information systems as well as systems that can exhibit a high degree of intelligent behavior. A hierarchical file system has been designed that provides automated migration of files between local storage and a centralized file system and, by FY 1982, implementation of this system will be completed. A kernelized secure operating system has been implemented, and the design of a secure distributed message system will be completed in FY 1982. The design of the ADA programming language was completed and accepted as a DoD standard. An ADA-based programming environment for distributed systems will be developed and demonstrated in FY 1982. Research results from this program will be transferred to the Services through the various testbed programs.

b. Computer Communications Technology. The packet communication technology program is exploring computer-based methods for controlling, allocating, and accessing a variety of information transmission media (e.g., mobile radio, broadcast satellites, coaxial and optical cable, leased telephone circuits). Collections of networks are interconnected to each other by means of small gateway computers. End-to-end security is being developed for these packet-switched networks, and applications such as multimedia message systems and real-time packet-switched voice are being developed for a multinetwork environment.

Packet technology forms a sound basis for supporting integrated voice and data communications in a multiple network environment. It is the only technology that can achieve both highly dynamic demand allocation of transmission resources and efficient utilization of communication

capacity while concurrently supporting real-time information exchange among people, among computers, and between people and computers.

Packet radio network control software is being implemented to permit highly survivable operation of a large number of packet radios; in FY 1982, a low-cost version of the packet radio will be developed. A remotely keyed end-to-end internet security system has been demonstrated and, by FY 1982, it will be certified for use at the Fort Bragg testbed. A new concept for robust satellite networking has been developed based on a large number of low-cost satellites capable of communicating with each other as well as with the ground. A narrow-band packet voice terminal has been developed; starting in FY 1981, it will be used for multi-user voice communications over a wideband (3 Mbps) satellite channel. Internet experiments will be conducted in FY 1981 and FY 1982 including electronic message forwarding, multimedia conferencing, and ARPANET connection to commercial packet-switched networks. Most of the technology developed in this program will be transferred to DCA and the Services through joint technology or testbed programs, but some will be transferred by means of the DoD protocol standardization effort for which DCA acts as the executive agent.

c. Strategic Laser Communications. The Strategic Laser Communications program is a joint DARPA/Navy effort to develop the technology necessary to provide essential communications support to submerged strategic missile submarines (SSBNs) without compromising their natural immunity to detection. This communication capability could be provided by blue-green laser pulses from satellites capable of penetrating clouds and water to reach the SSBNs. The laser pulses could be provided directly from a

satellite-based laser, which would be constrained to very low power by current space power systems and limited laser efficiencies, or from a higher power, ground-based laser reflected from a low technology space-based relay mirror. The program is investigating key technology elements to determine the best candidate for an early end-to-end communication demonstration.

A fully deployed system would provide three payoffs essential to the maintenance of our strategic forces: (1) continued invulnerability of our SSBNs through decreased detection opportunities; (2) increased robustness of the strategic C^3 system itself, possibly providing continuing command and control into the trans- and post-attack periods; and (3) a wide range of tactical applications.

The Strategic Laser Communications program draws on an unusually broad technology base for its implementation. Blue-green laser device technology has focused on excimer and solid state lasers developed over the years by DARPA, DOE, and the Services. Other technology elements include adaptive optics for atmospheric turbulence compensation; wide field of view, narrow-band optical receivers; and construction of comprehensive communication link models that utilize the optical oceanographic and meteorological databases developed over the years. Major accomplishments include the demonstration of laser pulse propagation through clouds and the development of an adequate, if limited, optical receiver for initial communication experiments in FY 1981. In these communications experiments, a blue-green laser beam will be transmitted from an aircraft through clouds and water to a submerged submarine. An improved optical receiver will be built for the space-based approach and for the ground-based approach.

Atmospheric compensation will be demonstrated in the laboratory in FY 1981 and in the field in FY 1982. The program will transfer to the Navy, in accordance with a Memorandum of Agreement, at the conclusion of the first full-scale end-to-end verification experiment.

D. ADVANCED CRUISE MISSILE PROGRAM

1. EEMIT or Demonstration Programs

DARPA is not currently funding any EEMIT or demonstration programs in this program area.

2. Technology Base (6.1/6.2) Programs

a. Autonomous Terminal Homing (ATH). The ATH program is developing and demonstrating critical technologies for an advanced, day-night and adverse weather, precision terminal guidance system for low-altitude cruise missiles. The guidance system uses an onboard infrared sensor to obtain images of the target area, which are then compared by means of advanced scene matching algorithms with prestored reference images that are generated in a highly automated reference preparation facility prior to launch. Also being pursued for the ATH sensors is a terrain-following/obstacle avoidance information capability that can significantly reduce cruise missile flight altitudes and, thereby, improve penetration survivability.

The technologies being developed are directly applicable to current and next generation cruise missiles. The resulting advanced guidance system will provide our cruise missiles with the required flexibility, accuracy, and penetration survivability necessary in the mid-to-late 1980s.

During FY 1980, two sensor types, two scene matching algorithms, the reference preparation approach, and the associated integration

contractor were selected based on previous sensor/scene matcher performance evaluations. Major efforts during FY 1981 include the fabrication of the imaging sensors, planning for the sensor flight test program, and development of a ground-based Scene Matching Laboratory. During FY 1981, the scene matching contractors will also complete the initial phase of their development effort. Reference preparation activities will include final development of automated processing techniques and the completion of an integrated reference preparation facility. Using data collected during the FY 1982 sensor flight program, the two competing scene matching algorithms will be evaluated in the Scene Matching Laboratory and a single sensor/scene matcher combination will be selected for continued development. This technology will be transferred to the Air Force Wright Avionics Laboratory for use in the advanced technology cruise missile.

b. Advanced Delivery Concepts. The Advanced Delivery Concepts program is investigating unconventional designs and launch modes as well as a variety of synergistic subsystem technologies to provide both substantial increases in range-payload and improved penetration capability for the strategic delivery vehicle. This program considers long range and low observables at low altitude to be essential features for the next strategic cruise missile. Advanced delivery vehicle design considerations include provisions for forward looking sensors, threat warning sensors, and onboard flight path optimization systems. The Advanced Delivery Concept project will provide a next generation cruise missile to counter evolving threats to the present cruise missile.

In FY 1980, the program investigated techniques to greatly increase range and to develop a cruise missile optimal flight path system,

developed techniques for cruise missile cost reduction and an employment concept for a nonnuclear cruise missile, and formulated requirements for a dispenser and penetrator munition. Under associated activities, the development of the cruise missile optimal flight path system is continuing with refinement of the algorithm and integration studies. The airframe contractors began integration studies for the autonomous terminal homing system and a terrain-following/obstacle avoidance system. Work will continue on the nonnuclear cruise missile with conceptual designs for dispenser and penetrator munitions. Efforts in terrain-following/ obstacle avoidance will also continue, together with bomb damage assessment system development.

The program will initiate the transfer of technology to the Air Force in late FY 1981/early FY 1982 through a vehicle technology demonstration program that will carry one contractor for an approximate 3-year flight demonstration phase.

c. Advanced Cruise Missile Engine. The Advanced Cruise Missile Engine program is developing a high payoff engine concept with a potential to utilize new high energy fuels, increased thrust, and a reduction in fuel consumption. Currently under investigation is a compound cycle turbofan engine (CCTE) that replaces the combustor of a typical turbofan with a two-stroke, high-speed (8000 rpm) diesel engine. This project is also investigating an excentric engine, consisting of a three-spool turbofan with the third spool (or high pressure compressor, combustor, and turbine) mounted off-axis to the other two spools.

The advanced cruise missile engine will enable the development of smaller vehicles (more per cruise missile carrier) as well as allow

more payload-range combinations for advanced cruise missile options. The increased payload will put larger nuclear warheads or conventional munitions on the target, and the increased range will provide both more flexible target routing and increased cruise missile carrier survivability by permitting the cruise missile to be launched further away from enemy perimeter defenses.

The development and testing of the CCTE single cylinder test rig is nearing completion. The CCTE will demonstrate forecasted engine speed, pressurization, and temperature. The design of the excentric engine third spool has been completed and fabrication has begun. Testing of the third spool at full operating pressure and temperature (2500°F) for one hour will take place with Columbium turbine blades in early FY 1981. The engine demonstration (validation phase), a 3-year effort to be initiated in FY 1981, will continue with the design and fabrication of the full integrated engine. Completion of the demonstration/validation is scheduled for mid-FY 1984 with a demonstrated thrust specific fuel consumption reduction from that of the current cruise missile turbofan engine.

d. Cruise Missile Detection Technology (CMDT). The DARPA CMDT program is designed to develop a strong base of understanding of the phenomena that determine the capability limits of those defensive systems used to counter cruise missiles. Radar masking, clutter, and propagation data, as well as infrared background data, are being collected and analyzed in order to establish such a base. The validated phenomenological data will be used to modify and refine models of defensive systems' performance so that the survivability rate of cruise missiles can be confidently predicted.

This program is providing the basic physical understanding of the effects that determine the limits of defensive systems. These results are being provided to the current and advanced cruise missile research, development, test and engineering community so that it can maximize U.S. cruise missile survivability against current and reactive defense systems.

The principal efforts in FY 1980 concentrated on measurements and analysis of both ground-based and airborne radar clutter and analysis and measurements of propagation phenomena. Studies of actual terrain masking and ground clutter, as well as predicted masking and clutter at specific sites, and analysis and measurements of infrared clutter background were also performed. An all-wheel-drive truck with an X-band radar and digital recording system measured and recorded clutter data at over 70 sites as a precursor to a more elaborate, five-frequency set of equipment that will visit these sites in early FY 1981. In FY 1982, the second phase of radar clutter and propagation measurements will be continued and infrared background measurements will be completed. Analysis, modeling, and measurements of the airborne look-down clutter will also be completed.

Although there is no plan to transfer this entire program to the Services, the results of the analyses, studies, modeling, and measurements have been and will continue to be provided to the Services and to those agencies and industries involved in U.S. cruise missile RDT&E.

E. LAND COMBAT

1. EEMIT or Demonstration Programs

a. Tank Breaker. The purpose of this program is to develop the technology for and demonstrate the feasibility of a next generation medium

antiarmor/ assault precision guided weapon system that is single manportable, shoulder fired, fire-and-forget, and capable of achieving high lethality against advanced armored combat vehicles and other targets in both open and urban terrain. NATO requires medium manportable antitank systems capable of defeating the Warsaw Pact armored threat. The objective of the Tank Breaker program is to eliminate the deficiencies inherent in currently fielded medium antiarmor weapon systems, command guided or laser beamrider weapon systems, and unguided antiarmor weapon systems by demonstrating an advanced manportable, shoulder fired, antitank/assault weapon system to defeat advanced armored targets.

The Tank Breaker program was derived from advanced imaging infrared focal plane array (IIR/FPA) technology developed under the DARPA Advanced Imaging Infrared program. The Tank Breaker program was initiated in April 1980 after concept definition studies and the results of captive flight tests of seekers developed under the Advanced Imaging Infrared Seeker program indicated the potential for an advanced manportable antiarmor/assault weapon system that would integrate emerging technologies for high density IIR/FPAs, advanced signal processing, missile guidance and control, reduced impulse launch mechanisms, progressive burning rocket motors, and advanced warheads in a low-cost, high-performance, day/night, fire-and-forget missile that would be a replacement candidate for the Dragon medium and antiarmor weapon system. Under Phase II of the program, four contractors began developing critical components of competing system concepts for IIR/FPA seekers, missile launch, and guidance and control. This phase continued into the second quarter of FY 1981 with comparative flight test and evaluation of lock-on-before-launch, fire-and-forget

seekers, missile launch, and flight control systems by the four contractors. Based on comparative test results and proposals for Phase III full-scale system demonstration, two contractors will be selected to develop and demonstrate their designs for the Tank Breaker missile. Advanced Phase II seekers will undergo a captive flight test, and eight controlled flight test vehicles also will be flight tested. Twelve advanced development Phase II Tank Breaker missiles, six from each contractor, will be tested in competition with the Army's candidates for the Infantry Medium Antiarmor/Assault Weapon System (IMAAWS). The program will transition to the Army when the winner of the competition enters engineering development.

b. Assault Breaker. The Assault Breaker program is developing and demonstrating technologies for standoff acquisition and destruction of armored formations beyond the forward edge of the battle area. The system includes Assault Breaker ground- and air-launched missiles and the associated Pave Mover radar. The long range airborne radar provides standoff surveillance to find and track targets and guidance for standoff missile attack or for penetrating aircraft direct attack of the targets. The missiles and their munition dispensers provide the capability for delivering terminally guided submissiles and submunitions to a high degree of accuracy and achieving a high kill probability.

From 1978 through the first quarter of FY 1980, initial component technologies were developed and demonstrated for the Pave Mover radar, T-16 Patriot ground-launched missile and munitions dispensers, and terminally guided submissiles and submunitions. In FY 1979 and 1980, tests of the munition dispensers at supersonic and high subsonic speeds proved the feasibility of stable, dispensing munitions in the flight regime of the

free flight missile. In FY 1979, captive flight and tower tests demonstrated the capability of the submunitions to acquire, home, and impact on targets; in FY 1980 free-fall flight tests of the infrared terminally guided submissiles were conducted by two competing contractors. Those free-fall flight tests using millimeter wave radar seekers were not successful, and that effort was terminated in late FY 1980. A second smart bomblet submunition for use against soft targets was successfully tested in February 1980 and selected for the flight demonstration. Roof House tests of the Pave Mover radar in FY 1979 proved that the goals could be met for target surveillance, target tracking, and weapon guidance. Development of two competing radars continued.

The ground-launched version of the Assault Breaker weapon system concept is being demonstrated at White Sands Missile Range. The two competing Pave Mover radars have been integrated in F-111 aircraft and are undergoing surveillance and target tracking tests that will qualify Pave Mover for tests with the Assault Breaker missile. Both the infrared terminally guided submissile and the smart bomblet submunition are completing full-function qualification tests at White Sands and Sandia Laboratories, New Mexico, to qualify them for the flight test program. The ground-launched Assault Breaker demonstration at White Sands is being conducted as a comparative evaluation of the T-16 Patriot and T-22 Lance II ground-launched missiles. Six missiles of each type are being fired in this phase of the program. The first two are being fired with inertial guidance to verify basic missile accuracy, demonstrate the capability of their dispensers to distribute dummy submunitions, and measure ballistic accuracy. The second two firings will evaluate the ability of the missiles to dispense

live submunitions and the ability of the submunitions to achieve a "kill" on stationary tank targets. The Pave Mover radar capability for tracking targets and the in-flight missile are also being evaluated. In the final two shots, the entire system will be evaluated against moving targets: the radar's ability to acquire and track a moving target and provide guidance to the missile; the missile's ability to guide accurately to the moving target and dispense its load of submunitions; and the submunition's ability to achieve multiple "kills" in the target area.

In order to demonstrate fully the weapon delivery options of the Assault Breaker concept, a joint test (DARPA and Air Force) of an air-launched version of the standoff missile will be conducted beginning in the first quarter of FY 1982. The test will consist of approximately six launches of the Assault Breaker missile from manned aircraft. Army T-16 missiles are being modified for air launch. The Pave Mover radar will provide target acquisition and guide the missile to target engagement by the seeker. Submunition dispensing and terminal effectiveness will also be demonstrated during these tests. The air-launched standoff missile flight test will be conducted from October 1981 through March 1982, in a parallel demonstration of the Pave Mover radar capability to guide penetrating manned aircraft for direct attack of targets.

The air-launched phase of Assault Breaker and the Pave Mover program will be transferred to the Air Force in late FY 1982 for further development of the Pave Mover system. Successful completion of the Assault Breaker technology demonstrations will provide a basis for decisions on engineering development for the corps support weapons system by the Army and for the Pave Mover radar by the Air Force in late FY 1982.

2. Technology Base (6.1/6.2) Programs

a. Hybrid Signal Processing. Hybrid signal processing combines the best features of analog and digital components, such as simple binary circuits with programmable analog circuits, to achieve processing gains that are not possible with conventional approaches. For example, it becomes possible to process coherent signals with bandwidths in excess of 100 MHz over virtually unlimited time periods. This technology can be applied to emitter locators, bistatic radars, and low-probability-of-intercept radars with waveforms capable of defeating next generation intercept receivers.

In FY 1980 and FY 1981, specific emitter locator and radar system configurations were developed, predictions for improvements in system performance were made, and laboratory devices were developed and tested. In FY 1982, a full analog/digital signal processor and support system will be developed and laboratory tested in preparation for a field demonstration in FY 1983. Following a successful field demonstration, this program will transition to such programs as the Assault Breaker radar and could form the basis for new intercept receiver and radar design concepts.

b. Cruise Missile Defense. The Cruise Missile Defense program is directed toward development of advanced detection and engagement concepts to counter the next generation cruise missile threat. This threat is characterized by low-altitude flight profiles and low cross-sections. Suppression of ground clutter returns and cross-section enhancement techniques are the principal technical challenges.

In FY 1980 and FY 1981, these detection and engagement concepts were developed and their performance was predicted via simulation and

analyses. Powerful clutter suppression techniques were designed and evaluated; critical components, such as analog-to-digital converters, were specified. In FY 1982, the design effort will be completed and promising techniques will be selected for field tests. Following field tests in FY 1984, this program will be transitioned to the Air Force.

c. Bistatic Alerting and Cueing (BAC). BAC is an outgrowth of the Sanctuary Bistatic Radar program described in last year's Congressional Statement. That program held successful field tests in FY 1980 and early FY 1981, and was transitioned to the Army and Air Force. BAC is a joint DARPA/Army program to provide timely and accurate alerting and cueing target information to such battlefield weapons as Stinger, DIVADS, SHORADS, and NURADS. This information is currently not available with the requisite timeliness and accuracy via existing C^3 links.

BAC uses existing monostatic radars, such as AWACS and SOTAS, as the illuminating source, with a small, lightweight, low-cost, bistatic radar receiver colocated with each fire unit or platoon. In addition to the projected improvement in engagement capability, BAC offers survivability improvements, since no radio transmissions are required from the weapon during the surveillance period. It also offers significant potential for an ambush capability.

The 2-year BAC program started in second quarter FY 1981; following successful field demonstrations in late FY 1982 and early 1983, the program will transition to the Army for incorporation into its SHORADS-C^2 testbed.

d. Surgical Countermeasures (SCMs). This is a joint DARPA/Navy electronic warfare program designed to enhance the performance of nearly

all types of deception electronic countermeasure (DECM) techniques, which operate against fire control radars and missile seekers. SCM attempts to "close the loop" between jammer and victim so that victim radar or seeker responses to DECM signals are detected and fed back to the jammer in real time. The jammer then uses this new information to control its operating mode, power, and waveforms. The technique applies principally to air-to-air radar combat, air-to-ground suppression of surface-to-air missile missions, and the defense of ships against cruise missiles.

In FY 1980, the SCM concept was successfully demonstrated in the laboratory. In FY 1981, fabrication was initiated for an SCM testbed for field demonstrations. Following successful ground tests in FY 1982 and airborne tests in FY 1983, the program will be transitioned to the Navy (mid-FY 1983).

e. Advanced Indirect Fire System (AIFS) Technology. The AIFS Technology program is a joint DARPA/Army effort to improve significantly the operational capability of cannon field artillery. The primary objective is to overcome the inherent range and accuracy limitations of cannon field artillery by developing and demonstrating advanced technologies in projectile propulsion and guidance and in infrared sensors and millimeter wave radar, autonomous lock-on, terminal homing seekers for cannon fired projectiles. The program will provide a technology demonstration of a lock-on-after-launch artillery projectile.

The fielding of this technology in a fire-and-forget cannon artillery projectile would provide a means to offset the numerical superiority of Warsaw Pact armored forces and artillery to those of NATO and to reduce excessive ammunition expenditures. The capability for autonomous

terminal homing would reduce the need for the observer to operate a laser designator for projectile guidance and increase significantly the capability for using unobserved, surprise fires.

This program was initiated in early FY 1979 in cooperation with the Army. Phase I concept definition studies of competing projectile/seeker concepts were completed in October 1980. Two prime contractors were selected for Phase II critical component development and demonstration, which emphasizes competition between two technology solutions to the operational requirements--an 8-inch projectile and a 155-mm projectile. Critical technologies were investigated for ramjet propulsion and flight control for the extended range, 8-inch projectile and system designs were developed for both projectiles. The fire-and-forget seeker concepts that were investigated included a scanning infrared seeker developed under the Air Force's Infrared Guidance Demonstration program, an IIR/FPA being developed under the Tank Breaker program, and two competing millimeter wave radar seekers. Critical issues for all seekers include the ability to survive the shock of being fired from a cannon and the development of microcomputer programs to provide autonomous identification and lock-on to targets and to provide guidance signals enabling the projectile to home on the target.

Phase II of the program continues through the end of FY 1981 with the captive flight test of competing concepts for autonomous, lock-on-after-launch infrared and millimeter wave radar seekers. Seeker developments and tests are coordinated with the Air Force Infrared Guidance Demonstration program, The Tank Breaker program, and the Wide Area Anti-armor Munitions program for the wide-angle self-propelled minimissile. Critical seeker and projectile guidance and control components are being subjected

to high gravity (10,000 g) tests in gun firings, as are components of the ramjet boosted 8-inch projectile. The ramjet projectile is being fired from an M110A2 8-inch howitzer to demonstrate the capability for ramjet survival of gun launch, ignition, and powered flight. Projectile guidance and control are also being demonstrated. Evaluation and demonstration of the critical component technology needed to achieve extended ranges with 155-mm autonomous terminal homing projectiles began in January 1981. In 1982, based on the results of the Phase II AIFS evaluation, a single projectile design and infrared and millimeter wave seeker designs will be selected for full-scale demonstration of an autonomous homing, extended range, cannon artillery projectile. Critical components will be integrated during FY 1982 into a full solution autonomous terminal homing, extended range, cannon artillery projectile that will be demonstrated in live firings in FY 1983. Successful demonstration of the technology could provide the basis for an FY 1984 engineering development decision by the Army and permit accelerated development and fielding of fire-and-forget, terminal homing, cannon artillery projectiles for the Army, Marines, and Navy.

F. NUCLEAR TEST VERIFICATION TECHNOLOGY

1. EEMIT or Demonstration Programs

a. Marine Seismic System (MSS) Demonstration. The MSS Demonstration program offers the possibility of monitoring unobtrusively at close distances the most seismically active regions for clandestine underground tests. The only solution to achieving the signal detection and counterevasion verification objectives required for that area is to position monitoring sensors in international coastal waters.

The MSS consists of a high quality, three component borehole seismometer and associated signal conditioning electronics suitable for long-term emplacement in the deep ocean floor. The seismometers will be emplaced in boreholes at a depth of several hundred meters drilled into firm bedrock to achieve the maximum isolation from background noise. Data will be transferred to a central analysis center either by bottom cable or by satellite link. The program will demonstrate the feasibility of installing and operating a state-of-the-art seismic detector in a borehole in the deep (5.6 km) ocean floor and will define seismic detection capabilities of such a system. The MSS will significantly enhance global monitoring of underground/underwater testing under a comprehensive test ban treaty and nonproliferation.

The MSS incorporates advanced sensor technology developed under a parallel DARPA research program. Application of the seismic data recorded by the ocean bottom deployed system to detection, location, and identification of underground explosions will depend on analysis techniques developed under the ongoing DARPA programs in seismic source and signal propagation theory and advanced data processing.

The program was initiated in late FY 1979 and the design for the system was completed at the end of FY 1980. Techniques and specialized equipment required for emplacing the instrument in boreholes in the ocean floor using the drill ship GLOMAR CHALLENGER have been completed. An at-sea test is to be conducted in the mid-Atlantic in March 1981 to verify the operation of this equipment and to gather initial data on the seismic noise reduction in this environment. The sensor and associated electronics required for data acquisition and storage will be developed by early 1982,

and deployment of the system is scheduled for the summer of 1982. Full system communications will be added in FY 1983.

2. Technology Base (6.1/6.2) Programs

a. International Seismic Data Center. At present, no facility exists that meets the technical requirements for effective collection, processing, and analysis of seismic data from a global network of diverse stations with widely varying instrument characteristics and data formats. The International Seismic Data Center program supports anticipated international treaty requirements and the need for advanced database handling capabilities to support development of more effective algorithms and signal processing techniques for regional seismic data. A prototype data center is being designed and developed that will be capable of handling the data of national seismic stations (NSS) as well as numerous research stations in the United States and other countries. This data center will incorporate advanced techniques in the collection, integration, processing, archiving, and distribution of seismic data. It will also serve as a testbed to develop new tools for analyzing data for verification and research purposes.

Preliminary design of the data center was completed in FY 1980 and major hardware components for each subsystem were defined and procured. Detailed design was begun for the Seismic Analysis Subsystem, the analysts' work station. During FY 1981, the hardware and software subsystems will be developed and integration will begin. By mid-FY 1982, the first operational version of the data center will be assembled. It will consist of the major subsystems linked together via a local computer network that will be developed in FY 1981. Data from a regional seismic

network will be acquired with this system, and testing and enhancements will begin in late FY 1982.

Potential operators of the system include the U.S. Geological Survey (USGS) and the Air Force. The design techniques utilized on the data center will be transferred to the Air Force, USGS, National Oceanic and Atmospheric Administration, and other U.S. agencies with a mission to acquire, process, and distribute seismic data.

b. Yield Estimation Research. This program supports basic research to improve the U.S. capability to estimate the yield of foreign underground nuclear tests using the characteristics of seismic signals recorded at long distances. Fundamental questions about the structure of the earth and the behavior of geologic materials render current seismic estimation of nuclear explosion yields uncertain. The objective of this program is to reduce those uncertainties by theoretical studies that will improve understanding of the physical processes involved in the generation and propagation of seismic waves by explosions and by conducting appropriate experiments to obtain necessary data. Current research is focused on developing a quantitative understanding and improving the methodology.

Past research identified the possible existence of systematic differences in the amount of attenuation of seismic waves. Quantitative estimates of the magnitude of the effect have been developed to correct this. Continuing research efforts are directed toward a refinement of this correction and the development of techniques using seismic data less influenced by this effect. Previously developed models of explosion sources and small-scale laboratory and field experiments are being applied to quantify the effects of near-source geophysical parameters such as rock

type, burial depth, and geologic structure that control the amplitude of the seismic signals from explosions. These sensitivity studies are being combined with information from studies of the geological and geophysical setting of U.S. and foreign explosion test sites to determine the effect on the seismic signals and to guide development of more accurate seismic yield estimation procedures.

G. SPACE DEFENSE TECHNOLOGY

1. EEMIT or Demonstration Programs

The Space Defense Technology programs are grouped into two major areas--high energy laser space defense and particle beam technology. The Talon Gold, ALPHA, and LODE projects, collectively called the "Space Laser Triad," are major demonstrations of the three key technologies required for a space-based laser. These three technologies are acquisition, precision pointing and tracking (Talon Gold), high efficiency infrared chemical laser devices (ALPHA), and mirror and beam control optics (LODE). The Advanced Test Accelerator (ATA) project, forming the major testbed portion of the DARPA Particle Beam program, seeks to demonstrate the feasibility of atmospheric electron beam propagation over distances of military interest.

a. Talon Gold. Significant improvements in fire control and precision beam direction must be achieved to enable a laser to be effective in space. The objective of the Talon Gold program is to develop and test the requisite capabilities including target acquisition, tracking, and precision pointing. The space test activities will consist of a low-power laser pointing experiment that utilizes a scaled acquisition, tracking, and pointing payload. The experiments will be conducted as a sortie flight of the space shuttle. The test program will utilize both high-altitude

aircraft and space targets to obtain realistic target kinematics, signature, and backgrounds. The performance goals of the experiments represent an improvement in high energy laser pointing and tracking. This experiment will establish the feasibility of achieving required fire control performance levels and will provide the necessary database for design of a first generation laser system.

The Talon Gold program utilizes laser radar techniques developed under its technology base program to achieve the required tracking precision. The potential of this approach was evaluated in a ground-based laser radar tracking program at the MIT Lincoln Laboratory, where enhanced signature satellites were tracked. Extensions of this technique in conjunction with improved inertial reference platforms, sensors, and alignment systems recently developed by DARPA and Service laboratories are expected to enable Talon Gold to achieve the required performance levels.

The Talon Gold program was initiated for DARPA by the Air Force Space Division. The contractors are continuing their activities through the preliminary design phase, including brassboard hardware development. The preliminary design review will be the basis for selecting a single contractor for succeeding phases. The Talon Gold experiment is now scheduled to be launched as part of the Air Force Space Test program. The results of this demonstration will be transferred to the Air Force and Army by direct dissemination of analyses of the design requirements, future system approaches, and potential performance of operational systems.

b. <u>ALPHA</u>. ALPHA is a ground-based chemical laser demonstration intended to establish the feasibility of a laser suitable for space operation. Its objective is to demonstrate the laser device technology in

extracting a high power beam. Emphasis in this effort is on the ground-based test and evaluation of a scalable laser.

Near-term mission applications of this program, which forms the laser device technology portion of the "Space Laser Triad," center on the demonstration of the laser device technology. The design concepts for ALPHA integrate resonators, optical bench, and alignment subsystems developed in the technology base program.

Nozzle technology scaling module tests and conceptual designs have been successfully concluded, and two of the three contractors were selected to proceed to preliminary design of the demonstration laser. Engineering drawings and their supporting analyses are being completed. The efforts will conclude with the selection of a single contractor to proceed to detailed design, fabrication, and testing. Following detailed design, fabrication will be initiated and preliminary design of the facility subsystems will continue. This program will transition to the Air Force upon demonstration of system feasibility.

c. Large Optics Demonstration Experiment (LODE). The LODE program will establish the feasibility of large aperture beam control for high-performance space systems. The demonstration hardware will be developed to meet stringent operational system requirements and will be extensively tested in sophisticated ground simulation and test facilities to establish actual performance levels. This program is being developed in conjunction with the companion DARPA technology demonstration programs in chemical lasers (ALPHA) and acquisition, tracking, and pointing (Talon Gold).

The LODE program will integrate significant advances in large mirrors, high-bandwidth fine tracking and beam stabilization, and advanced structures into an ultra-high-performance electro-optical system. A major element of this program is the development and optical testing of a complex mirror, based on advanced technology developments, to meet stringent weight and optical performance requirements. After development testing with a subscale mirror, the beam control system will be integrated and extensively tested in a large-scale thermal-vacuum ground facility that simulates as fully as possible the space environment and the dynamic target engagement.

This effort will contribute substantially to the sequential development of large mirrors and higher performance beam control systems for advanced space lasers.

The success of the LODE program depends considerably on the achievements of technology base programs in large optics technology, adaptive optics, lightweight space structures, and high bandwidth control systems, among others. Of particular note are the excellent results achieved in a series of programs entitled "Large Optics Technology" that established the feasibility of ultra-lightweight "frit-bonded" glass mirrors and thoroughly defined the major trades in fashioning the leading candidates for the LODE mirrors. Other DARPA technology programs in high-speed control system modeling, precise vibration isolation systems, adaptive optics sensors, optical components and coatings, and holographic gratings are the basis for improving beam control performance. Several Military Department programs such as SRAT and ADABECS (Air Force) and SEALITE (Navy) form the

foundation and provide the basic technology for the beam control concept currently evolving in LODE.

Dual concept definition studies, aimed at defining the LODE technical requirements, design concepts, and test and simulation hardware have established design requirements traceable to the operational system concept and have provided critical inputs to the process of selecting the primary mirror. Selection criteria have been established in the areas of mirror design trades, production alternatives, system sensitivity to mirror type, and the impact of the mirror decision on test and simulation options. DARPA is now in the process of making the final selection for the primary mirrors. The final design of the LODE hardware and related test program will be initiated with a single contractor. During the years of the actual LODE hardware demonstration, the mirror and beam control technology will be transitioned to the Air Force for ground-based systems integration and ultimate space demonstrations.

d. Advanced Test Accelerator (ATA). When completed at the end of FY 1982, ATA will be a critical experimental tool for demonstrating the scientific feasibility of propagating intense relativistic electron beams within the atmosphere. This device will be the free world's most powerful accelerator. ATA will provide the essential scientific data required by the Services to plan preprototype weapon developments. Initial experiments will evaluate a preliminary propagation mode, and the beam parameters will be modified in subsequent tests to provide assessment of propagation modes that may provide improved performance.

Electron beams, which deliver large amounts of energy at velocities near the speed of light and deposit them deep within a target,

offer a wide range of potential applications. These beams could provide point defense of naval assets against nonnuclear threats and defense of hardened sites against nuclear attack and could provide point defense of naval assets and moderately hardened targets against nuclear attack. Theoretical and experimental research programs directed toward demonstrating the propagation of charged particle beams in the atmosphere have been under way for over 20 years. These efforts have been limited to demonstrations of stable beam propagation at low pressures due to the absence of accelerators capable of providing high energy current and pulse repetition rates at sufficient beam energy. Sophisticated theoretical models have extrapolated these data to predict the beam parameters required for stable propagation at atmospheric air densities. In addition, the necessary accelerator technology to produce these parameters has been perfected and demonstrated with the experimental test accelerator at Lawrence Livermore National Laboratory. This technology is now being incorporated into the ATA.

The program to construct the ATA began in mid-FY 1979 and is scheduled for completion at the end of FY 1982. The design of the accelerator was completed during FY 1981. The building and tunnel, which will house the accelerator, as well as most major hardware procurements are being completed during FY 1981. Efforts during FY 1982 will be directed toward assembly of the system components and operational checkout of all subsystems. Work to achieve operation of the accelerator at full specifications and initial beam propagation experiments will be performed in the following year. DARPA is currently working with the Navy, Air Force, and

Army to plan important experiments and to prepare for transition depending on evolving mission requirements and the success of feasibility experiments.

2. Technology Base (6.1/6.2) Programs

The space defense technology base programs establish the necessary basic technology for the more advanced demonstration programs. The objectives of these efforts are to develop (1) the basic technology to permit advances in laser optical components and ultra-precise laser beam pointing; (2) improvements in near-term chemical and far-term visible laser device efficiency, wavelength, and waveform; (3) the scientific feasibility of charged particle beam weapon concepts for atmospheric and space applications; and (4) the utilization of visible blue-green lasers for strategic submarine communications.

a. Advanced Laser Optics. The laser optics technology base program supports new and innovative ideas in the areas of high-performance laser mirrors, optical coatings, optical fabrication of complex resonator mirrors, advanced structural modeling, and sensors and control systems for adaptive optics subsystems. A major element in this program is the Large Optics Diamond Turning Machine (LODTM) being developed and constructed at the Lawrence Livermore National Laboratory for precision optical fabrication of suitable mirrors. This program contributes directly to the optics technology required by the LODE program and the Chemical Laser Device Technology Demonstration program (ALPHA). These efforts also provide the technology foundation for extrapolating to large-scale laser weapon concepts for antiaircraft applications and ballistic missile defense.

The preliminary design for the LODTM was successfully completed in early FY 1981; the final design is scheduled for mid-FY 1981; the construction of the building to house the diamond turning machine is now underway; and the fabrication of machine components will be completed in FY 1982. Several other technology base efforts will yield technology demonstrations in the following areas in FY 1981: beam stabilization using holographic gratings, use of self-referencing Hartmann sensors to provide target imaging data, simulation of complex optical-structural interactions of beam control hardware with computer models, and the feasibility of using thinned multiple mirrors for projection optics in large laser systems. The Small High-power Optics Program (SHOP) has completed preliminary designs on competing small cooled-mirror concepts and the design will be completed in mid-FY 1981, the hardware in early FY 1982, and performance testing by late FY 1982. In late FY 1981 and early FY 1982, new programs will be initiated in the areas of infrared optical coatings, aperture sharing devices, measurements of the vibration output of chemical laser devices, and optical polishing and metrology techniques for conical resonator optics. Technology base results are transitioned continuously to the LODE and ALPHA demonstration programs by formal interface meetings and technical design reviews.

b. Acquisition, Pointing, and Tracking. Advanced space-based lasers will require acquisition, pointing, and tracking performance levels beyond those that are currently projected for the Talon Gold demonstration. Substantial improvements in pointing precision and the development of rapid acquisition and retargeting capabilities will be necessary. In response to these projected requirements, DARPA has initiated advanced technology

programs in the areas of advanced acquisition and tracking approaches, target identification, aimpoint selection, and precision pointing mounts.

During the period from FY 1980 to FY 1981, the acquisition and tracking technology base development included the evaluation of a technique for rapid acquisition and tracking using reflections of the high energy laser beam from the target. Improved algorithms for the tracking of faint targets have also been developed. During FY 1981, an advanced precision brassboard model will be completed. Additional acquisition and tracking brassboard activities will be initiated to continue the development of precise, rapid retargeting capabilities.

c. Device Technology (Chemical Lasers). The objective of the Chemical Laser Technology Base program is the resolution of the critical chemical laser device efficiency, wavelength, and waveform. In addition to providing the technology base for the ALPHA demonstration project, this program is continuing to advance component technology with scaled laboratory testing of advanced resonator concepts. Such testing includes evaluation of optical-transfer laser devices and injection-locked concepts.

Laser component testing completed in FY 1980 verified that the high fuel efficiency performance data obtained previously with subscale nozzle arrays apply to high-power laser devices. In addition, unconventional, so-called "source-flow" nozzle concepts have been developed which equal, and in some cases exceed, the performance of conventional nozzles.

In FY 1981, laboratory testing will be completed for the resonator concepts, and physical optics models of annular resonator performance will be validated. In FY 1982, advanced resonators and performance models for chemical lasers will be developed in addition to completion of testing of new annular laser resonator concepts on CO_2 laser testbeds.

Gain medium and resonator performance model validation will be completed using data acquired with CO_2 testbeds.

d. Visible Lasers. The DARPA Visible Laser program is directed toward development of the technologies required to demonstrate the feasibility of using long range, ground-based visible lasers for strategic applications.

The major thrusts of the Visible Laser program are development of two techniques with potential for scalability to the efficiencies and power levels required for operational use. Major accomplishments of the FY 1980 program include subscale demonstration for many of the repetitive pulse techniques needed to fabricate a large single pulse laser and preparation for proof-of-principle experiments to demonstrate predicted performance parameters of one of the selected laser techniques. In FY 1981, energy will be extracted from the second selected laser approach to confirm single pulse scaling projections and efforts to demonstrate repetitive operation will begin. In FY 1982 and beyond, both techniques will be progressively scaled to demonstrate operational usefulness. Subsequent experiments will demonstrate scaling to the visible spectrum and will be used to address preliminary system design issues. A visible laser beam control program will also be initiated during FY 1982 to resolve detailed component and system design issues. The Visible Laser program is developing technologies that can eventually transition to all three Services.

H. SPACE SURVEILLANCE

1. EEMIT or Demonstration Programs

a. Teal Ruby Experiment. Teal Ruby is a space-based experiment, incorporating first generation DARPA advanced infrared technology,

which will be launched by the shuttle in 1983 and operate in space for a minimum of one year. The sensor utilizes the "staring" concept for detection of dim aircraft targets against the earth's background clutter. Teal Ruby is the primary payload of the Air Force Space Test Program satellite P80-1. The DARPA Infrared Technology program is based on the concept of multimission strategic surveillance from high-altitude space platforms. The stabilization and pointing system of the Teal Ruby Experiment is designed to emulate the geometry of such a platform from a 400-nmi orbit. Because of the lower altitude, a modest sized telescope and a smaller "staring" focal plane can be used. Teal Ruby's primary mission is to provide a proof-of-concept for spaceborne detection of strategic aircraft. In addition, Teal Ruby will provide proof-of-concept for other multimission surveillance functions, develop a comprehensive and global radiometric background data base, and space qualify first generation advanced infrared surveillance technology.

The Teal Ruby Experiment was made possible by technology base programs at DARPA and the Services. Development of the infrared sensitive charge coupled devices (IRCCD) was conducted by DARPA under the STARE program and the HALO technology program. These developments made feasible the fabrication of the Teal Ruby focal plane as the first large-scale implementation of a two-dimensional infrared detector array. The DARPA HALO technology program developed the lightweighting techniques used to design and manufacture the Teal Ruby telescope.

During FY 1980, the automated mosaic detector array tester, a critical element in the manufacture and qualification of the large number of integrated devices required for Teal Ruby, was checked out and certified.

A qualification model infrared telescope was fabricated and successfully tested in a simulated space and space-launch environment. The qualification model sensor was assembled and environmental testing at the system level was initiated. In FY 1982, qualification testing will be completed, and the flight model sensor will be assembled, tested, and prepared for integration with the USAF P80-1 satellite for an FY 1983 launch.

The Teal Ruby technology and experiment results will be transitioned to the Air Force via the Advanced Space Application program.

b. Advanced Sensor Demonstration. The Advanced Sensor Demonstration program is a space-based experiment incorporating second generation DARPA infrared staring technology. It is an integrated spacecraft sensor that will be launched to synchronous orbit in 1988 and is expected to function for more than 2-1/2 years. The experiment is sized to allow detection and tracking; the preliminary configuration of the sensor payload incorporates a telescope with optical filters, a focal plane, a cryogenic refrigerator to cool the focal plane, and a processor that controls the system and converts focal plane data into target track information for use by small ground terminals.

The primary thrust of the effort is to provide system level proof-of-concept for a number of military surveillance missions. The flight demonstration of various DARPA technologies designed into experimental subsystems in an integrated surveillance platform is of great value to follow-on operational military systems. Subsequent operational military sensor system developments will also require the database of target signatures and backgrounds being developed in this program. In aggregate, this effort will reduce the cost and complexity of subsequent operational

systems. In addition, this experimental spaceborne sensor will be available for observation of critical events anywhere in the world during most of the system's life. The ability to track selected targets will enable an evaluation to be made of the utility of space sensors to strategic and tactical air war scenarios as well as to fleet defense.

Technology development to support this experiment was carried out under the DARPA Space Surveillance and Advanced Optics Project (ST-2) in Program Element 62301E. Component developments for lightweight optics, detector arrays, signal processors, optical filters, and cryorefrigerators were initiated and demonstrated under the HALO technology program. This flight experiment was made possible by achieving major technology milestones in FY 1978 and 1979.

A preliminary experimental concept has evolved and the system requirements review has been completed. Significant intermediate milestones in the cooler, processor, and detector array development programs have also been achieved. A preliminary system design review is scheduled, and detailed system design work will be pursued in preparation for a formal system design review.

2. Technology Base (6.1/6.2) Programs

a. Space-Based Radar. This effort is designed to eliminate the technical risk associated with a space-based, phased array radar. Developments have been in progress since FY 1979 in such critical areas as transceiver modules, antenna membranes, and target identification. The program is oriented to complete component technology and will consider major subsystem development. This technology will contribute to development of an agile beam radar that can detect and track bombers and ships. The primary

missions include fleet defense and CONUS air defense. Presently, several major milestones have been achieved: A three-layer antenna membrane has been developed and tested that is considered a breakthrough in space antenna development. In the area of transceiver development, significant breakthroughs have been achieved in the areas of weight and cost. These results have made it possible for this technology to be applied in areas other than space-based radar, e.g., ballistic missile defense and tactical aircraft radars. As a result, this technology is being transitioned to the Services as it develops.

b. High Resolution Calibrated Airborne Measurement Program (HI-CAMP). The HI-CAMP sensor is an advanced, infrared measurement system designed to make high resolution (spectral, spatial, and temporal), two-dimensional measurements of earth backgrounds and mobile and stationary air, sea, and land targets. The HI-CAMP sensor has two types of advanced two-dimensional monolithic infrared arrays with charge coupled device multiplexers capable of providing data in two broad infrared bands. It is integrated into the lower hatch of a high-altitude aircraft to make measurements above most of the earth's atmosphere.

HI-CAMP will demonstrate the infrared charge coupled device (IRCCD) technology and develop a two-dimensional database of high spectral, spatial, and temporal resolution background and selected target measurements. Furthermore, HI-CAMP will provide fundamental atmospheric, target, and background measurement data; assess advanced focal planes, signal processing, and tracking algorithm developments; and support advanced technology programs associated with advanced surveillance concepts. This information is vital to support the Strategic Technology Office advanced

surveillance programs such as the Teal Ruby Experiment, the Advanced Sensor Demonstration program, and the HALO Technology program.

The HI-CAMP sensor is the first proof-of-principle for staring mosaic IRCCD sensors and has measured the infrared signatures of aircraft, surface, and sea targets. Many of these measurements were coordinated and supported by the Services. A substantial background suppression factor was demonstrated in FY 1980. A new, more sensitive focal plane will be designed and developed to demonstrate background suppression and to measure dim targets against highly structured backgrounds.

The technology of the HI-CAMP sensor and the data measured are being transferred to the Services via technical direction meetings, reports, and presentations at classified symposia.

c. Monolithic Gallium Arsenide (GaAs) Integrated Circuits (ICs). These circuits are based on GaAs rather than silicon and offer substantial speed and/or power advantages if the problems in fabrication that control circuit yield can be resolved. The DARPA program addresses numerous technology problems in GaAs circuits by executing a program of broad scope covering basic materials advances, novel processing technology, and development of new circuit concepts.

The results of this program will permit space surveillance programs to meet their goals for low-power and high-radiation-tolerant signal processing digital integrated circuits. Furthermore, the process technology underlying the DARPA program of direct ion implantation into semi-insulating GaAs substrates has been adopted industry-wide and is utilized by R&D programs of all three Services and the intelligence community. Solid-state radar transceiver ICs are also evolving from this research and

will affect space-based radar, airborne radar, and electronic countermeasures systems. A complete technology for monolithic GaAs LSI circuits and microwave circuits has been demonstrated. Key elements of this accomplishment include a method for qualifying GaAs semi-insulating substrates as IC worthy, use of direct ion implantation into these substrates to form circuit elements, and a truly planar circuit topology that promises high circuit yields. The level of integration has been advanced nearly an order of magnitude during every year of the 3-year DARPA program. The effort has culminated in a fully operational 8 bit x 8 bit multiplier that provides a 16-bit product every 5.2 nanoseconds. Aside from the high speed of these GaAs circuits, their expected radiation tolerance has been verified, i.e., there is no change in operating characteristics after 4×10^7 RADs (GaAs) of ionizing radiation. Portions of this program are being transferred to the Strategic Technology Office of DARPA (digital ICs and microwave circuits) (FY 1982) and to the Naval Air Systems Command (microwave circuits) (FY 1981).

I. TECHNOLOGY INITIATIVES

1. EEMIT or Demonstration Programs

DARPA is not currently funding any EEMIT or demonstration programs in this program area.

2. Technology Base (6.1/6.2) Programs

a. Electromagnetic Force (EMF) Gun. The EMF Gun program is jointly sponsored by the U.S. Army Armaments Research and Development Command (ARRADCOM) and DARPA. This program explores uses of alternative electromagnetic propulsion techniques for military gun and launcher applications. The primary purposes of the program are to demonstrate a unique

EMF laboratory launcher system to accelerate an appropriate payload, and to develop a subsequent technology demonstration system for air defense, armor, or artillery applications. In principle, the exit speed of projectiles launched by electromagnetic means is not limited, as in the case of conventional gun systems.

By the end of FY 1981, the EMF laboratory hypervelocity launcher system will be assembled and preliminary commissioning tests will be completed. Twin rail guns will be used to launch scaled gliders with high payload efficiencies. New designs for advanced homopolar generators (energy storage systems) were completed in FY 1979; detailed engineering drawings of the generators were completed in FY 1980; and fabrication of a new generator was initiated in FY 1981. Also, projectiles are being launched from linear rail guns. In early FY 1982, the EMF laboratory launcher system will be transferred to the Army/ARRADCOM and will be reassembled in minimum time so that the planned experiments can continue. In preparation for the initiation of the technology demonstrator phase of the program, technical efforts will focus on outstanding relevant component issues.

b. Ballistic Intercept Missile. A technology base is being developed within the Ballistic Intercept Missile program to provide a capability for long range fleet and CONUS defense. Key technologies under development are the sensor and navigation system for control of the weapon during the end-game kill. Three combined sensor and navigation concepts were identified in FY 1980-FY 1981. Development of these concepts will be carried through detailed design. A single concept will be selected for fabrication and flight test prior to transfer of the technology base to the Air Force.

c. Distributed Sensor Networks. The Distributed Sensor Network program is investigating a survivable surveillance concept based on the use of packet radio technology to link together multiple low-cost distributed sensors. The goal of the program is to develop a system architecture that is capable of detecting as well as tracking individual targets such as low-flying air vehicles. A fully distributed low-cost surveillance system offers a nonnodal, highly survivable system that can be installed, repaired, and upgraded modularly. It appears to be the most effective approach for detection and tracking of low-flying air vehicles, and the architecture can be adapted to many other surveillance situations.

A six-node distributed sensor network architecture is under development. The first three nodes will be fielded in FY 1981 for testing. Efficient distributed signal processing algorithms have been developed and will be evaluated in the testbed environment. Distributed machine intelligence techniques are also being developed for situation assessment. The major contribution of this program will be a system architecture for distributed sensor networks, which will be investigated jointly with the Services for application to specific problems involving low-flying aircraft and underwater surveillance.

d. Nondestructive Testing and Evaluation. A scientific foundation for ultrasonic acoustic emission and electromagenetic nondestructive measurement techniques is being developed. This technology, combined with failure models and accept/reject decision criteria, will provide a new capability for increasing safety, reducing costs, and increasing the usability of DoD systems.

This joint DARPA/Air Force effort will emphasize development of these technologies to demonstrate retirement-for-cause as a new method of achieving longer life from F-100 engine disks. This will permit us to obtain the maximum safe life from each system component by discarding only those components that do not have sufficient remaining life for return to service. The current procedure is to retire all engine disks in the fleet after a predetermined amount of time. When this technology is used by the Air Force, the maintenance costs for the F-100 engine alone will be reduced by $5 to $10 million per year.

The conceptual design phase of this program is completed and the development of the specific technologies required to meet the program objectives is under way. In addition to the continuation of the DARPA nondestructive evaluation science base, the retirement-for-cause program will enable the characterization of defects in materials and the evaluation of them against specific requirements. As part of the joint program, the Air Force is supporting a manufacturing technology program to produce the necessary equipment to use retirement-for-cause at an Air Logistics Center in 1985.

e. Distributed Training Technology. The development of an instructional system for wide geographical distribution is based on two technical advances: (1) microprocessor technology to produce small, portable, personalized job performance aids for maintenance technicians and operators; and (2) the application of videodisc technology to the production of ultra-low-cost training simulators for areas such as tank gunnery, ground tactics, and air combat. Sensitivity analyses with a quantitative model of combat readiness and effectiveness indicate that these two areas

contribute most heavily to improved job performance and training and, therefore, to improved tactical performance, maintenance readiness, material flow, and combat readiness and effectiveness. Distributed Training Technology addresses the DARPA thrusts of Naval Warfare--through its possible application in an aircraft carrier-based multi-echelon training system--and Land Combat--with the tank gunner simulator.

DoD residential training costs are estimated at $7.2 billion with 15 to 20 percent of DoD personnel involved in training at any point in time, exclusive of such considerations as field exercising, on-the-job training, and factory training. Distributed Training Technology will bring the schoolhouse to the student, greatly improve effectiveness, and significantly reduce training costs and time.

In the training/authoring area, development, evaluation, and transfer of computerized systems have been completed. Prototype development of advanced, intelligent, small, portable, personal job performance aids (e.g., for vehicular maintenance), and the development of prototype ultra-low-cost simulators (e.g., for tank gunnery based on the use of videodisc technology for image display) have been achieved. In FY 1982, testing of the small, portable, intelligent, personal job performance aids and low-cost simulators will be completed in the context of a distributed instructional system for the Services. The job performance aids and simulator technology will be enhanced according to operational test results.

Elements of the Distributed Training Technology program have been and will be transferred to the Services, and training research is closely coordinated on a continuing basis.

f. Teleconferencing Technology. The objective of this program is to develop and demonstrate a low bandwidth video teleconferencing technology for crisis decisionmaking that requires no user training, provides for natural conference control (e.g., directed gaze, gestural addressing), incorporates meeting aids to facilitate group decisionmaking, and satisfies the unique requirements of those crisis situations in which each member of the decisionmaking group is at a different location. This objective is accomplished by the development of a novel video teleconferencing system that simulates, through the use of conferee surrogates to create a shared virtual space, a natural proximate conference in which all of the conferees would be gathered around a common meeting space through the development of a unique image coding algorithm that permits the transmission of video sketches at 9600 bits per second. The illusion of a proximate conference is further enhanced by providing each conferee with a shared graphical workspace or electronic blackboard that can be used to access many kinds of pictorial, graphic, and alphanumeric data, and which also permits the conferees to simultaneously and conjointly annotate visual materials, sketch, and prepare outlines and notes.

Group decisionmaking is an integral part of the command and control process. However, current command and control system design has not directly addressed the problem of how geographically dispersed decisionmakers can be linked for effective group decisionmaking in times of crisis beyond providing a variety of communication means and data management systems. The advanced video Teleconferencing Technology program represents the first serious effort to address this problem, and the development of a

technology for the low bandwidth transmission of video provides a means that is both consistent with military operational constraints and economically responsible.

During FY 1980 to FY 1981, a five-station local video teleconferencing system was developed based on the shared virtual space concept. This system incorporates bandwidth compression and advanced media aids for multisource data retrieval, display, data sharing, joint document production, and meeting control. A three-station distributed video teleconferencing system operating over commercial telephone lines also was developed to assist in identifying problems associated with constructing a prototype distributed DoD system. During FY 1982, the design of the local and distributed experimental teleconferencing systems will be enhanced, as indicated by experiments planned for FY 1981 and early in FY 1982 and through the addition of improved bandwidth compression devices and conference aids (most notably, an improved high-resolution electronic "blackboard" and an innovative acoustic management system). Experiments will be conducted with the enhanced systems and a design will be developed for a prototype distributed DoD teleconferencing system during the out-years. In FY 1983, a DoD operational environment will be selected for installation of the prototype video teleconferencing system, and the system will be installed and evaluated in FY 1984.

g. Radial Wafer Blade. The Radial Wafer Blade program is supported jointly by DARPA and the Air Force. Efforts include the development of vastly improved vane and blade alloys for jet engines through rapid solidification rate technology, new cooling designs based on bonded wafers, and demonstration of the process with scale-up to production volume

requirements. The program will demonstrate a high durability component for the F-100 engine in the 1985 time frame. In addition to component performance improvements through a combination of rapid solidification technology and more effective component cooling, significant production cost savings and reduced use of critical materials such as cobalt and chromium will be realized.

Accomplishments to date include a significant improvement to the rapid solidification rate powder-making equipment through the installation of a helium gas recirculator. This will greatly expand the powder production capacity and reduce costs. Two radial wafer blades have been run in an F-100 test engine, including 25 Tactical Air Command full mission cycles. Blade alloy optimization studies have resulted in a tenfold improvement in oxidation resistance without sacrificing high-temperature strength. A vane alloy has been developed that has intrinsic oxidation resistance that is better than many coatings that are currently used. Rapidly solidified alloys have exhibited the ability to be cold-rolled to final wafer thickness, which will lead to improved process control and further cost reductions. Transition plans include component performance demonstrations in an advanced turbine engine and development of complete component processing specifications.

h. Space Signal Processing. The Space Signal Processing program is designed to develop an advanced onboard signal processor (AOSP) that is optimized to support military space missions through the year 2000. The processor will have multimission capability; will be power, weight, and volume conservative; and will be able to survive 10 years in space without performance degradation. For surveillance missions, this processor is

designed to process the raw data onboard the satellite and to relieve the communication system of the need to transmit large amounts of data, thus greatly decreasing the space resources allocated to the communication function. For communications missions, this processor will enable considerable sophistication in beam agility, null forming and steering, spread spectrum coding, and multiple access, all of which will protect the communication system from jamming and other electronic countermeasures.

This processor was initially designed to process the raw data for space-based radar. As the design matured, it became clear from analyses that the design was general enough to encompass all of the known space signal processing requirements foreseen through the year 2000. The initial design of the processor has been completed at both the register and gate levels and includes several levels of support simulation. Breadboard construction has begun on the array computing element, which is the building block in the AOSP design. Efforts have also started on GaAs circuit development to provide greater capability and higher radiation resistance.

This program is a jointly funded DARPA/Air Force effort as part of the Air Force Space-Based Radar program.

i. Fiber Optic Sensor Systems. The Fiber Optic Sensor Systems program is a joint Navy/DARPA directed research effort to exploit the effects of various energy fields on the optical signal in a fiber waveguide. The thrust of the program is to improve passive detection, localization, classification, and tracking of energy weapon platforms using an entirely new class of multifunction (i.e., acoustic, magnetic, thermal, and rotational) sensors with the potential for direct coupling to optical cabling and high-powered optical processors. These sensors will be

geometrically flexible, lightweight, low cost, reliable, extremely sensitive, and invulnerable to electromagnetic/radio frequency interference and electromagnetic pulse.

To date, the program has (1) demonstrated better than sea-state zero equivalent noise performance in an acousto-optic glassboard (i.e., optical breadboard) sensor by replacing laboratory optical components with state-of-the-art optical devices; (2) improved minimum detectable acoustic pressure in fibers by 2-1/2 orders of magnitude; (3) enhanced the acousto-optic coupling coefficient of coated fibers by more than an order of magnitude; (4) demonstrated laboratory magneto-optic sensor capability within 5 dB of theoretical prediction; and (5) demonstrated unique opto-electronic components for generic sensor applications.

The DARPA-funded materials research, conducted by the Tactical Technology Office and the DARPA Defense Sciences Office, will transition to the Navy's Fiber Optic Sensor Systems exploratory development in FY 1983.

j. Target Penetration Research. Basic research has been initiated during FY 1981 to provide fundamental improvements in shaped charge warhead and kinetic energy penetration technologies. The research is being conducted to expand scientific knowledge and to provide a technology base for improved warhead and penetrator effectiveness. The new warhead concepts being investigated offer a potential to significantly improve terminal performance against advanced armor arrays.

k. Technology Innovation Search. With the current emphasis on achieving technological superiority to offset Warsaw Pact weapons and manpower, it is imperative that DoD be cognizant of the military-oriented research and development work that is being conducted by industry and

universities that are beyond the purview of DoD. DARPA has, therefore, established a program to aggressively search for and exploit evolving commercial and university research that has military applications. This program, in effect, increases the level of military R&D funding or extends the effect of existing research resources by introducing new and creative ideas into the DoD mainstream--ideas that might have never surfaced without extensive, duplicative DoD efforts.

The Technology Innovation Search program was initiated in February 1980 to identify, review, and transfer selected U.S. commercial technology to DARPA or the appropriate Service laboratories for application to specific defense problems. The results from this program are expected to provide a significant military research resource multiplier. For example, recently discovered commercial developments in ceramic fibers and in reinforced injection molding processes relate directly to aircraft design and defensive weapons systems and help to eliminate redundant, overlapping research efforts.

A significant portion of the U.S. industry does not perceive military markets as sufficiently rewarding to offset the frustrations and burdens imposed by DoD regulations and paperwork. Military research programs are often viewed as less certain, slower to obtain, intermittent, and restrained in profit.

These factors have served to block the transfer of commercial technology to DoD. DARPA's innovative search methodology offers a structured search for technical innovations or concepts within the private sector that alleviates many of the negative psychological barriers that the non-DoD industrial sector has encountered and, thereby, expedites the transfer of technology to DoD.

Some promising matches that are evolving rapidly are (1) the initiation of ceramic fiber technology transfer to the Army Ballistic Research Laboratory; (2) the submission of five proposals to DoD and other federal program managers on the subject of high-power solid-state lasers; and (3) in the area of reinforced reaction-injection molding, the consideration of mixing technology in mold for potential application to a DARPA investigation of liquid propellant gun techniques.

During FY 1981, DARPA sought to try out and adopt new methods for the Technology Innovation Search program to screen technologies more precisely and to strengthen the technology transfer mechanism. DARPA and Service laboratories are being exposed to commercial technologies at near zero cost and are increasing their application of private sector research.

1. Machine Intelligence. Machine intelligence research combines fundamental investigations of the limits of the digital computer's capabilities for intelligent information processing with relevant military concept demonstrations. The program is developing ways to acquire large bodies of specialized knowledge in computers and to efficiently bring that knowledge to bear on the complex and dynamic problems of situation assessment, planning, and control in the command and control environment. The goal is to make it possible for computers to assist and/or relieve military personnel in complex or routine decisionmaking tasks that are information intensive, personnel intensive, tedious, dangerous, or in environments that can present unexpected situations.

Success in this effort will amplify our ability to interpret and act upon information in many forms--text, imagery, sensor signals,

databases--in an intelligent and timely manner. Military applications of the technology include intelligent remote sensors, cartography, adaptive network communications, and a wide range of command and control situations.

A bootstrap stereo technique has been developed that extracts terrain information from a sequence of images taken from a single camera mounted on a moving platform. A system that permits natural language access to distributed databases has been demonstrated and is being adapted for portability. A knowledge-based system for automatically integrating multisensor data from electronic warfare was developed and tested; its performance matched or exceeded that of a human's ability to interpret and respond to incoming data. In FY 1982, there will be a concept demonstration for an automated intelligent system for tactical air battle management, and an intelligent display-based information presentation system will be completed that includes a natural language interface for control of the display format.

This technology is being transferred to the Services through testbed programs such as the ACCAT and the cartographic work station being developed jointly by DARPA and the Defense Mapping Agency.

m. Very Large Scale Integration (VLSI) Research. The VLSI research program is developing methodologies, innovative architectures, and computer-aided design and process simulation tools to exploit VLSI technology. Custom VLSI chips are being designed and fabricated to explore innovative architectures; the goal is to develop VLSI systems with a million or more gates on a chip that represent fundamental advances in processing capability. Fundamental research on critical silicon VLSI fabrication processes will provide scientific insight and lead to increased circuit yield and reliability.

The circuit design and fabrication times and the cost of providing custom VLSI chips for military systems will be significantly reduced through the use of network-based design methodologies, support systems, and process simulation aids being developed under this program. Various innovative architectures such as the tree machine and the geometry engine are being explored to exploit VLSI technology. When combined with advanced processing control capability, these will lead to signal/data processing systems having small power, weight, and volume requirements, but with orders of magnitude greater processing capabilities than current LSI techniques permit.

A new ultra-high frequency transistor, called the permeable base transistor (PBT), is believed capable of operating at frequencies above 500 GHz. A preliminary version of the PBT has been developed and demonstrated to operate at frequencies above 30 GHz. A technique has been developed for restructuring a large-area integrated circuit after initial fabrication, and in FY 1982 it will be used to demonstrate restructurable logic with a 100,000 transistor circuit. A new computer architecture called a tree machine is being developed for highly parallel computations, and a working version will be demonstrated in FY 1982. More than 150 copies of the second edition of the silicon process simulation program have been distributed to and are in use by DoD agencies, government laboratories, and their industrial and university contractors. Significant new scientific insight has been gained into the physical processes controlling silicon oxidation, the most important circuit fabrication step. Concepts are being transferred directly to U.S. semiconductor industries as they are developed. Several industries already are using the process simulation

program for commercial purposes The smallest feature (0.1 micron) silicon transistor ever fabricated was realized through a highly innovative process technology that uses conventional optical lithographic techniques. The feasibility of using highly focused ion beams to fabricate submicron feature devices without the use of photomasks was demonstrated.

n. Particle Beam Technology. The objective of the Particle Beam Technology program is to determine the scientific feasibility of both charged and neutral particle beam concepts. The critical issue for charged particle beams is to demonstrate stable, predictable propagation of relativistic electron beams in the atmosphere. The thrust of neutral particle beam research is to demonstrate the capability of generating low-divergence beams for potential space applications.

Particle beams offer the capability to rapidly deliver large amounts of energy and deposit them within a target to provide high kill probability. Potential applications of charged particle beams include antiship missile and hard site defense. Neutral particle beam potential space applications include ballistic missile defense.

Charged particle beam research efforts have provided experimental data at low electron beam energies and low gas densities. These data have been extrapolated by means of sophisticated theoretical models to predict stable propagation in the atmosphere. This research has also provided the advanced high-current linear induction accelerator technology that is essential to demonstrate propagation at full atmospheric air densities. Advanced accelerator technology has been evaluated and perfected during FY 1980 and 1981 with the experimental test accelerator at Lawrence Livermore National Laboratory. This device, which has operated within

90 percent of the design goals of beam current, forms the basis for the design of the Advanced Test Accelerator Demonstration program, as well as providing an experimental facility for the completion of low pressure electron beam propagation research during FY 1982. The neutral particle beam research program, which was transferred to DARPA from the Army in FY 1981, focuses on theoretical and experimental studies to minimize beam divergence in radio frequency ion beam accelerators. An accelerator test stand, which is being constructed during FY 1981 and 1982 at Los Alamos Scientific National Laboratory, will provide the essential experimental tool for evaluating critical beam divergence issues for the initial stages of potential high energy neutral particle beam systems.

DARPA is currently working closely with the Air Force and Army to plan important experiments and to prepare for transition, depending on experimental results and evolving application requirements.

III. UNIFIED AND SPECIFIED COMMAND ASSISTANCE

DARPA technology investment demands that our programs have high military utility against future threats and contribute meaningfully to the U.S. technology base. Within selected DARPA programs, the opportunity exists to apply results at the request of Unified or Specified military Commanders. Recent discussions with CINCPAC, CFC-K, EUCOM and SAC Headquarters have resulted in requests for DARPA recommendations for technology application in several mission areas.

A. PACIFIC COMMAND (PACOM) AND CFC-K

As indicated in Section I, automated message handling experiments were conducted at Hq PACOM to assess the utility of providing interactive computer message handling for the Unified Commander. These experiments, operated at the secret message level, were conducted by CINCPAC personnel. Significant command/control time savings were noted. At the request of CFC-K, an assessment of Command defensive capabilities was made. It indicated that DARPA-developed technology could improve needed surveillance, targeting, and communication capabilities. The following technology areas were assessed and resulted in recommendations.

1. Surveillance, Targeting and Communications

There are a number of programs in the process of being transferred to the Services that can fulfill expressed CFC-K mission needs for wide area, long duration surveillance; detection and validation of fixed and moving targets; and high volume tactical communications and data processing in an electromagnetic combat environment. The following demonstrated technologies are considered feasible and appropriate candidates for application to CFC-K needs.

a. Focal Plane Array (FPA) Technology. The extension of infrared surveillance, target acquisition, and tracking to new classes of important military targets has been made possible by the revolutionary DARPA development of infrared charge coupled device (IRCCD) technology. Single integrated chips containing a large number of infrared detectors have been packaged into multi-element FPAs that have demonstrated an increase in sensor sensitivity. The reduced size and weight and improved performance of sensors utilizing FPA technology are being applied to tactical target acquisition (see item II.E.1.a). Further application to remote target sensing for land combat applications can be accomplished to provide a substantial improvement in survivability as well as target acquisition and tracking for fire support elements.

b. Netted Radar. A joint DARPA/Army Netted Radar program was initiated during FY 1978 and successfully demonstrated at Ft. Sill during FY 1979 (refer to item IV.h). The improved capabilities that can be achieved by applying advanced digital signal processing technology to ground surveillance radars by netted operation include increased coverage and reduced vulnerability to countermeasures. This technology is being incorporated into the Army Netted Universal Radar program.

c. Packet Radio. Experimental packet radio technology has been developed and demonstrated to provide computer-aided communications for mobile users. The DARPA/Army packet radio experiment (refer to item II.C.1.b) is in daily use in garrison at Ft. Bragg and will be used to support field exercises through 1982. The impact of a mobile data communications capability on operations and access to remote automatic data processing capabilities have been significant. Application of this technique

can provide a reliable, antijam and anti-intercept data communication capability for C^2 at the corps and higher echelon headquarters. In addition to these DARPA developments, a netted ground and airborne radar network was recommended that would operate with a commercially available but developmental target analysis and planning system (TAPS). This equipment consists of a low-cost tabletop computer, computer memory systems, and a display that provides essential fusion of critical tactical C^2 information. This system was successfully evaluated in the NATO exercise ABLE ARCHER during November 1980.

2. Hard Structure Munitions

Selected munitions were adopted by Sandia Laboratory for the Pershing II earth penetrator and can be delivered by surface-to-surface rockets, aircraft, and artillery. By using precision guidance, only a small inventory would be required.

B. EUROPEAN COMMAND (EUCOM)

DCINC/EUCOM requested an evaluation of the EUCOM logistics system and recommendations on the appropriate application of information processng technology. A proposed testbed logistics network was designed that would link several U.S. sites in Europe. Interactive access to geographically distributed logistics computers would be provided for substantially improved logistics management. If the testbed is approved, funding and implementation will be provided by EUCOM. The availability of PACOM message handling experimental data to EUCOM J-3 was a significant help in the specification of EUCOM automated logistical message handling and the ultimate design of the testbed.

C. STRATEGIC AIR COMMAND (SAC)

A detailed discussion of DARPA information processing technology recommendations to Headquarters, SAC, is provided in item II.C.1.c. These recommendations are directed toward a desired order-of-magnitude improvement in management of mission planning and execution in the post-1990 period. As indicated in Section II, the worldwide distribution of C^3 forces will require intensive use of automated information collection, storage, and processing to provide SAC with realistic mission options in the 1990s.

IV. PROGRAMS TRANSFERRED

a. Ultraviolet/Visible Laser Components. The Ultraviolet/Visible Laser Components program investigated and identified candidate mirror substrate materials, window materials, and coatings for use in high energy excimer lasers operating in the ultraviolet or visible spectral region. The component technology will be transferred as part of the Ultraviolet/Visible Laser program, funded by the DARPA Directed Energy Office, to the Air Force for strategic space applications and to the Navy for submarine communication by conversion to the blue-green wavelength.

b. Teal Amber. The Teal Amber program has developed and demonstrated an advanced visible IR sensor technology suitable for rapid search surveillance of very dim space objects from a ground-based telescope. Unique mosaic focal plane and signal processing devices were developed for an experimental sensor system. Two field demonstrations of the camera system were successfully completed at the Air Force Experimental Test Site at Socorro, New Mexico. Plans for transfer of the experimental sensor and supporting equipment to the Air Force for operational use at the MOTIF site on Mt. Haleakala, Maui, are being made. This will complete the transfer of the program to the Air Force.

c. Compensated Imaging. About one-half of the DARPA Maui Optical Station was transitioned to the Air Force Aerospace Defense Command at the end of FY 1979. Because of the current projected use of the remaining portion of the facility, primarily in support of the compensated imaging field unit and laser beam propagation experiments, the remaining portion will not be fully transitioned; rather, it will be operated as a cooperative R&D facility with the Air Force. Joint operations between DARPA

and the Air Force over the past year indicate that this will be a very workable relationship.

d. Teal Ruby Experiment. Transition of the Teal Ruby Experiment to the Air Force is continuing. The Advanced Space Applications program, funded by the Air Force, will provide for detailed analysis of Teal Ruby data in the context of a possible operational air vehicle detection system. Contractual work on data and analysis began in FY 1981 with participation in mission planning. In FY 1982, the Teal Ruby Experiment will be delivered to the Air Force for integration on the P80-1 spacecraft.

e. Large Optics Materials. The Large Optics Materials program is developing materials for large-scale mirrors for space surveillance and high energy applications with low coefficients of thermal expansion. The materials technology developed under this program will be transferred with the Large Optics program funded by the DARPA Space Defense Technology program.

f. Hydrogen Fluoride (HF)/High Energy Laser (HEL) Film. The purpose of the HF/HEL Film program was to develop coatings for optical components such as mirrors and windows in high energy HF/deuterium fluoride lasers operating in the infrared spectral region. This technology has been transferred to the Air Force Weapons Laboratory where research programs are currently in progress.

g. Seaguard/Acoustic Research Center (ARC). The ARC advanced acoustic signal processing testbed will officially transfer to the Navy Undersea Surveillance Office at the end of FY 1982. This gives the Navy a unique and proven facility capable of developing advanced computer data processing algorithms using actual sensor information without degrading operational capabilities. DARPA will continue to support advanced

technology development at the ARC, but the future facility development and direction will be provided by the Navy.

h. Netted Radar. This program was initiated in FY 1978 to improve acquisition of tactical ground targets over wide geographic areas through the use of netted radars. The system concept was successfully demonstrated at Ft. Sill in FY 1979 with two modified PPS-5 radars; and again in FY 1981 with the PPS-5 radars, a TPQ-36 mortar locating radar, and an airborne radar simulating SOTAS. The following targets were automatically detected, tracked and located: moving vehicles, personnel, helicopters, shell bursts, and jammers. The key to these demonstrations lies in the development of a compact, moving target indication digital signal processor for ground clutter suppression. This development yielded a "clean screen" display, which allowed narrow-band (voice grade) data transmissions and subsequent track correlation/formation at a central site. Following the FY 1981 field demonstrations, the program was transferred to the Army, which has incorporated the technology into its Netted Universal Radar program.

i. Computer-Based Indication and Warning Systems. Two quantitative, interactive, computer-based monitoring and warning systems are being used to provide U.S. Commands with a different perspective on situations of current concern and for monitoring and warning. FY 1981 performance evaluations of the systems using classified data will have a significant effect on a decision to maintain them.

j. Counter-Terrorism Technology. The Terrorism Research and Analysis Project (TRAP) currently consists of a database and an interactive, microprocessor-based information storage and retrieval system that

serves as the research foundation for counter-terrorism decision-aiding models and for an indications and warning prototype system. The TRAP data, software, and research results are being incrementally transferred to DA/SOFD-D, JSOC, OJCS/PSYOPS, DNA, EUCOM/SOTFE, MAC, and DOE. Uses include training, monitoring, contingency planning, and storing user data.

k. Battlefield Exploitation and Target Acquisition (BETA)/ Coherent Emitter Location Testbed (CELT). The BETA program is a joint DARPA/Army/Air Force effort to develop and subsequently acquire a tactical correlation/fusion center that accurately reflects the air/ground combat situation in near-real time. The testbed consists of two correlation centers (one tailored for use at the tactical Air Force level and the other at Army Corps level), a communication system, and a number of remote display systems to provide interaction between the correlation centers and other users. CELT was a joint program to develop a system to accurately locate narrow-band communication emitters for eventual exploitation. Both the BETA and CELT technologies were transferred to the Army and Air Force in FY 1981. The BETA technologies transferred were primarily the computer software capability to merge information from different databases into a coherent view of the battlefield. The CELT effort transferred the technology required to accurately locate narrow-band communication emitters based on a single intercept.

l. Active/Passive Location. This program is an effort to locate, classify, and target critical nodes in the first and second echelon. Critical nodes include such force elements as nuclear support centers, air defense command posts, fire support and maneuver command posts, assembly areas, choke points, reconnaissance and radio electronic

centers, and others. Many critical nodes will be classified by simply plotting the type and number of emitters and their approximate location on the battlefield. Other nodes will require confirmation to provide node classification because not all nodes have unique signal characteristics. The FY 1981 effort will consist of a detailed system study to define the engineering requirements and will be jointly funded by DARPA and the Air Force.

m. Radial Wafer Blade Technology. The Radial Wafer Blade Technology program is being transferred to the Air Force over a period of several years through joint funding. DARPA is providing funds for program research to demonstrate that the radial wafer blade can operate in the F-100 engine for a longer time, at a higher temperature, and for a lower production cost than current generation blades.

V. PROGRAMS TERMINATED

a. Oceanographic Detection and Categorization System (ODACS). During FY 1980, DARPA terminated the ODACS program. Program objectives included the fabrication of a high-power blue/green laser radar and the installation of this unique device in an appropriately modified aircraft. The laser radar development was found to be more complex and costly than originally anticipated, and the power level precluded the achievement of program test and evaluation objectives. The technology developed from this program is being applied to the DARPA Strategic Laser Communications program.

VI. DARPA FISCAL YEAR 1982 BUDGET REPORT SUMMARY

A. OVERVIEW

We are requesting $655.0 million to implement the R&D program thrusts, as outlined in Section II, which represents an increase of $96.4 million over our approved FY 1981 appropriation. As shown in the following Budget Summary, this provides real growth of nearly 8 percent over FY 1981. DARPA's real growth over the past 10 years has been 4.4 percent per year.

BUDGET SUMMARY

Major Programs	Agency Fiscal Year ($ in millions) 1972	1981	1982	Agency Trends % Real Growth (Constant) FY 72-82 (FY 72 $)	FY 81-82 (FY 81 $)
Research	35.4	97.7	95.0	2.5%	(10.5%)
Exploratory Development	173.7	256.4	313.8	(1.6%)	12.6%
Experimental Eval Projects	--	197.7	238.4	--	10.9%
Mgmt Hdqtrs	3.3	6.8	7.8	0.1%	5.5%
TOTAL AGENCY	212.4	558.6	655.0	4.4%	7.9%
Agency budget as a percentage of DoD Science and Technology Program	14.7%	17.5%	17.3%		

The major contributor to this growth has been the Experimental Evaluation of Major Innovative Technologies (EEMIT). With respect to the overall DoD Science and Technology Program, the DARPA portion is about 2.6 percent higher than it was 10 years ago.

Of the $96.4 million increase requested by DARPA, $40.7 million is for EEMIT. This program element contains projects aimed at demonstrating key technologies that hold the promise of options for revolutionary new

system capabilities. The programs that account for this increase are Forward Swept Wing, X-Wing, the Advanced Sensor Demonstration, the High Energy Laser Space Defense projects, and two new programs transitioning to the demonstration phase in FY 1982--Tank Breaker and Indirect Fire Cannon.

Other major increases in the long-term Exploratory Development area that should be highlighted are:

- An increase of $27.2 million in the Strategic Technology program element. This supports the expansion of the Acquisition, Tracking and Pointing Program; the Ballistic Intercept Missile Program sensor development; and technology efforts for strategic deterrent programs that will require hardware procurements for testing.
- $19.0 million in the new Particle Beam Technology program element, which has transferred the Charged Particle Beam project from Basic Research (6.1).

The table below summarizes our budget request by program element:

PROGRAM ELEMENT FUNDING SUMMARY
($ in millions)

Program Element	Title	FY 1982 Descriptive Summary: FY 1981 Estimate	FY 1982 Estimate	FY 1983 Estimate
61101E	Defense Research Sciences	97.7	95.0	100.5
	Materials Sciences	24.1	31.5	33.1
	Advanced Systems Materials	(9.7)	(13.6)	(15.3)
	Electronic & Optical Devices	(14.4)	(18.0)	(17.8)
	Cybernetics Sciences	10.6	14.2	14.5
	Computer & Communications Sciences	27.3	34.2	37.1
	Intelligent Systems	(14.1)	(16.3)	(17.5)
	Advanced Digital Structures and Network Concepts	(13.2)	(17.9)	(19.6)
	Tactical Technology Research	5.3	13.1	13.5
	Unconventional Detection Research	(3.8)	(8.6)	(9.0)
	Target Penetration Research	(1.5)	(4.5)	(4.5)
	Charged Particle Beam	28.6	--	--
	Geophysical Research	1.8	1.9	2.3
62101E	Technical Studies	3.1	3.2	3.3
62301E	Strategic Technology	111.9	139.1	154.2
	Advanced Strategic Concepts & Strategic Technology Analysis	(3.0)	(1.0)	(2.6)
	Space Surveillance and Advanced Optics	(19.4)	(16.5)	(11.2)
	High Energy Laser Technology	(21.3)	(30.6)	(39.4)
	Strategic Deterrent	(3.8)	(8.1)	(10.9)
	Strategic Delivery Vehicles	(28.5)	(37.0)	(44.4)
	Warning Technology	(9.0)	(8.2)	(6.3)
	Space Application Technology	(2.9)	(6.9)	(6.1)
	Space Object Identification	(3.2)	(2.6)	(2.1)
	Strategic Laser Communications	(20.8)	(20.2)	(31.2)
62702E	Tactical Technology	80.0	81.8	96.7
	Target Acquisition & Engagement	(17.2)	(19.1)	(15.5)
	Weapon Technology & Concepts	(31.8)	(32.7)	(33.6)
	Ocean Monitoring & Control	(31.0)	(30.0)	(47.6)
62707E	Particle Beam Technology	--	19.0	20.1
62708E	Integrated Communications and Control Technology	35.3	41.6	44.2
	Distributed Information System	(13.9)	(16.1)	(17.4)
	Advanced Communications & Control & Communications Technology	(19.1)	(23.0)	(24.3)
	Systems Cybernetics Technology	(2.3)	(2.5)	(2.5)
62711E	Experimental Evaluation of Major Innovative Technologies	197.7	230.4	233.7
	Teal Ruby Experiment	(23.5)	(20.2)	(8.2)
	X-Wing	(2.9)	(12.9)	(3.5)
	Advanced Command & Control Architecture Testbed & DNA Testbed	(4.0)	(3.2)	(1.4)
	Technology Assessments	(1.6)	(1.7)	(1.7)
	Advanced Sensor Demonstration	(17.3)	(40.8)	(64.3)
	Space Acquisition, Tracking and Pointing Experiment - Talon Gold	(18.3)	(21.5)	(26.6)
	High Power Chemical Laser Ground-Based Demonstration - ALPHA	(18.6)	(22.5)	(25.7)
	Forward Swept Wing - Demonstration	(7.0)	(18.5)	(23.5)
	Assault Breaker Demonstration	(51.8)	(10.0)	--
	BETA/CELT Demonstration	(1.4)	--	--
	Large Optics Demonstration Experiment - LODE	(11.2)	(15.2)	(16.7)
	Indirect Fire Cannon	--	(10.0)	(7.0)
	Tank Breaker	--	(23.4)	(13.0)
	Classified Programs	(40.1)	(38.5)	(42.1)
62712E	Materials Processing Technology	11.9	13.5	14.0
62714E	Nuclear Monitoring	14.2	15.6	16.5
	Detection & Discrimination Research	(8.2)	(10.1)	(8.6)
	Yield Estimation Counterevasion Data Analysis & Processing Research	(6.0)	(5.5)	(7.9)
65898E	Management Headquarters (R&D)	6.8	7.8	8.1
	TOTAL DARPA	558.6	655.0	691.3

B. MAJOR THRUST DESCRIPTION

The following discussion provides more detail on key efforts in the DARPA program. In each case, the funding change is identified by major thrust with a description of the thrust and the major programs that make up the increase. A summary of the DARPA program by major thrust is provided below:

MAJOR THRUST SUMMARY
($ in millions)

Major Thrust	FY 81	FY 82	Change
Naval Warfare	38.2	51.1	+12.9
Air Vehicles & Weapons	43.0	55.0	+12.0
Command, Control & Communications	75.8	85.5	+ 9.7
Advanced Cruise Missile	45.9	56.9	+11.0
Land Combat	98.6	84.2	-14.4
Nuclear Test Verification	16.9	17.6	+ 0.7
Space Defense	70.2	98.0	+27.2
Space Surveillance	75.6	92.9	+17.3
Technology Initiatives	87.6	106.0	+18.4
Management & Support	6.8	7.8	+ 1.0
TOTAL DARPA	558.6	655.0	+96.4

1. Naval Warfare

This thrust investigates new technologies and concepts to improve the performance of passive acoustic systems, develop active acoustic surveillance technologies, and explore nonacoustic submarine signatures and long-range, over-the-horizon surveillance of air, surface, and submarine targets. The thrust increase is related to nonacoustic ASW, and advanced undersea vehicle programs.

2. Air Vehicles and Weapons

This addresses innovative concepts such as the X-Wing and the Forward Swept Wing technologies, air breathing missiles, and rapid solidification of super alloys, which could offer dramatic improvements in

aircraft performance. Increases relate to these programs and the convertible engine program.

3. Command, Control and Communications

Covered in this thrust are technologies for strategic laser communications, survivable computer communications, secure message and information systems, improved crisis management and command systems, and evaluations of these emerging technologies for efficient inter- and intra-theater communications and battle management in a quasi-operational test-bed. The Low-Cost Packet Radio C^3 systems architecture, system and network security, and spatial database management programs account for the increase in this thrust.

4. Advanced Cruise Missile

This thrust area investigates engine improvements for greater range and payload, enhanced homing, and guidance technologies to improve accuracy, advanced engine cycles, and the understanding of detection and tracking phenomena to maintain the ability of cruise missiles to penetrate a sophisticated air defense. The thrust increase is attributable to detection technology, engine development and propulsion, and power materials programs.

5. Land Combat

This thrust area covers a spectrum of target acquisition and weapon delivery technologies that provide new capabilities. These technologies are incorporated within advanced fire-and-forget missiles, advanced anti-armor warheads, Assault Breaker, all-weather targeting and guidance, and low-cost, longer range artillery rounds. The Tank Breaker, Indirect Fire Cannon, Guided Anti-armor Mortar Projectile, Advanced Armor,

and Penetrator Warhead programs account for the increase, which is more than offset by the decrease in the Assault Breaker program.

6. Nuclear Test Verification

Developments in methods and data analysis techniques for remotely determining the characteristics of nuclear tests and for verifying other nations' compliance with agreements limiting nuclear testing are addressed in this thrust area. The increase relates to efforts in the explosion field experiment, ocean-based surveillance, and advanced detection sensor areas.

7. Space Defense

This thrust focuses on high efficiency lasers, large space optics, and pointing and tracking techniques to demonstrate the feasibility of high energy laser system technology for space-related applications. Program increases are in the various laser component efforts.

8. Space Surveillance

This thrust addresses development of selected sensor technologies for target detection, improved missile surveillance, and new options for early warning on both strategic and theater levels. The Advanced Sensor Demonstration and the Teal Ruby program account for the increase in this thrust.

9. Technology Initiatives

This thrust includes programs such as innovative computer science; new communications technology; development of charged particle and neutral particle beam technologies to demonstrate the feasibility of propagating a high energy beam through the atmosphere; application of image understanding techniques to photo-interpretation automation; initiatives in

digital structure designs, cruise missile defense, electromagnetic propulsion and electronic and optics materials research; and "seed bed" technology programs. Increases are related to advanced digital structures, electromagnetic gun, artificial intelligence, cruise missile defense, space signal processing, PACSAT, VLSI circuits, and materials research efforts.

10. Management and Support

This thrust provides for the management and administration of Headquarters personnel including salaries, rent, travel, supplies, and equipment.